Peter Kropotkin
Ecologist, Philosopher and Revolutionary

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Certificate of Originality

I hereby declare that this submission is my own and to the best of my knowledge it contains no materials previously published or written by another person, nor material which to a substantial extent has been accepted for the award of any other degree or diploma at UNSW or any other educational institution, except where due acknowledgment is made in this thesis. Any contribution made to the research by others, with whom I have worked at UNSW or elsewhere, is explicitly in the thesis.

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(Signed)……………………………

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Abstract

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The Problem Investigated:

This thesis is conceived as: [1] a work of scholarship and exegesis [2] an examination of more recent scientific works which use similar metaphors or concepts, eg. Cooperation, that are central to Kropotkin's thinking.

As a work of scholarship and exegesis this thesis is *an attempt to present the many areas/dimensions of Kropotkin's philosophy and thinking in a systematic way*. I do not believe that this has been attempted previously in any language. Although his political, social and economic theories have generated a substantial secondary literature, Kropotkin's scientific works and philosophy of science, with the exception of his famous book, *Mutual Aid*, have received virtually no attention. In consequence of this the emphasis of this work will be upon his scientific writings. However, his political writings will also be examined as well as related to his broad scientific outlook.

In addition to evaluating Kropotkin's scientific works in relation to his period I also discuss them in relation to contemporary debates. Although not strictly true, the second half of this thesis is not a work of historical scholarship but an attempt to bring together the ideas of scientists that in one way or another support a Kropotkinesque characterisation of natural processes.

Although Kropotkin is often rightly regarded as a founder of modern environmentalism, this is difficult to substantiate from his purely political and social

writings. Thus I will attempt to present the core concepts of Kropotkin's anarchism in a coherent and succinct way with an emphasis upon showing how they relate to contemporary debates and perspectives within the environmental movement.

The Procedures Followed:

The thesis will be introduced biographically. This seemed the best way to introduce Kropotkin's works to the reader and place them in relation to one another and in their historical context. Thus the primary purpose of this historical section is to contextualise the great diversity of works by Kropotkin.

As I do not have a science background, but also for reasons of clarity, the remainder of the analysis shall be based upon the least technical and most accessible scientific literature in the various disciplines investigated.

I will begin by systematically collecting, cataloguing and analysing both Kropotkin's works as well as the secondary literature and then proceed to make some overall sense of them and then relate them to contemporary debates upon process and organisation in nature and society.

The General Results Obtained:

My research has revealed a large body of scientific work by Kropotkin. My analysis of them shows that he had a deep understanding of the role of mutualism, symbiosis, dynamism, group and social behaviour etc., in relation to physical and biological processes. His ideas, although necessarily containing errors, are broadly, as well as in many detailed aspects, consistent with the findings of professional, though often unorthodox, scientists of the present day.

The main faults of Kropotkin's approach was a fundamental failure to appreciate the role of territories and hierarchies in animal groups and his excessive progressivism.

My research also reveals how Kropotkin’s social vision, although somewhat utopian, can be sympathetically interpreted in terms of modern environmentalist perspectives.

The Major Conclusions Reached:

Kropotkin’s diverse works in science and social theory when presented systematically reveals that he is a philosopher of considerable interest in respect to both contemporary and historical debates concerning sociality and its influence upon the evolution of life on Earth.

Chapter One

The Life and Ideas of Peter Kropotkin

Prince Peter Kropotkin was born in 1842 to an ancient aristocratic family whose line stretches back to the Viking founders of Moscow. His mother, who is honoured in his *Memoirs* for her great warmth and compassion, unfortunately died when he was very young. His father, Kropotkin relates, was rarely present and a pathetically conservative man who had lived a cloistered military life. A strict disciplinarian, he ruled his children by fear and desired that all of his sons should follow a military career. The only toys he ever provided to them were a rifle and a sentry box. What might have been a somewhat barren and emotionally starved childhood and youth was to a great extent compensated through Peter's strong emotional and intellectual relationship with his older brother Alexander.[1]

The passage of his early life was finally sealed at the age of eight when Tsar Nicholas I became momentarily enchanted with the little boy at a ball. The emperor decreed that he be inducted into the *Corps de Pages.* This was then the most prestigious military academy in Russia. It not only supplied personal attendants to the imperial family but also secured an excellent and extremely lucrative career at court or in the military. Peter rapidly came to detest the military regime of the academy, which imposed discipline like a regular military unit. The academy provided, however, excellent teachers and a surprisingly wide and liberal education. Peter was thus able to endure a life-style which would have proved intolerable had he

[1] For an account of Peter's childhood relationship with his brother see the first few chapters of M. Miller, *Kropotkin*, Chicago; University of Chicago Press, 1976. This book originated from the author's Ph. D. thesis on the formative years of Kropotkin's life.

not been able to retreat into a private intellectual world that he lovingly shared with his brother. Despite frequent brushes with authority, Peter graduated in 1862, first in his class, winning thereby the position of *page de chambre* to the Emperor. This position involved close personal contact with Tsar Alexander II. From the viewpoint of the society into which Peter had been born, such honours would have been the envy of his peers. Peter, however, found that he could not bring himself to respect the Tsar and was stifled by the petty intrigues of court life.

Peter would dearly have loved to withdraw from military life and continue his mathematical studies at university. His father, however, would have refused to support his son through university had Peter chosen to give up such an obviously promising military career. He had no choice but to continue along the path set for him, but he did not pursue it in the way that his father would have liked or his peers expected. Prudence demanded that he enter one of the élite regiments surrounding the Court. It was, however, a special privilege of the graduates of his academy to choose any branch of the military service. His adventurous and rebellious character led him to apply to the Siberian regiment, selecting the Mounted Cossacks of the Amur. Siberia was even more remote in the mid-nineteenth century than it is today. It was not in any way considered a desirable place for a young prince to go. The regiment was a newly formed and highly disreputable one. Such a choice rather blatantly exhibited a conscious wish to end a more than promising military career. It was only through impressing the commander of the school with his bravery and organisational capabilities during a fire that he was ever granted permission to go to Siberia. Apart from his need to rebel, Peter disliked city life, desired to live amongst the people and was strongly motivated to do something useful. He thought that there would be useful things to do at the frontier of an expanding Russian empire. He hoped that he would find solace, freedom and adventure in the great and unexplored wilderness of North-East Asia.

As early as 1855 Tsar Alexander II told an assembly of Moscow nobles that it was better to abolish serfdom from above than to wait for it to abolish itself from below. The Act of Emancipation of February 1861, which was the Tsar's personal initiative, constituted the official transition from the feudal to the capitalist regime. Although the peasant reforms did absolutely nothing by way of raising the living standards of the peasantry (in fact quite the reverse), it was regarded by even the most ardent revolutionaries of the time as an enormous step forward. Kropotkin, in his childhood, had sympathised with Herzen's liberalism and was actually at the Tsar's side whilst the reforms of 1861 were being conceived and implemented. In the wake of the Emancipation Act the Tsar became, for a while at least, a hero to the youth of Russia. Kropotkin for a short period was likewise in awe of the Tsar. Even before he left for Siberia, however, he had become convinced, through his personal contact with him, that the Tsar was incapable of peacefully overseeing the social reform of Russian society. The Tsar did not in actual fact have the conviction to make the reform process work and very soon he began to brutally suppress any expression of liberal sentiments. The Russian empire became a police state and turned a large number of otherwise peaceful but idealistic young Russians into rebels, martyrs and violent revolutionaries and terrorists.

The events of the French Revolution had transformed the social life of Western Europe. It beckoned the Russian youth who felt paralysed by their country's decaying and unworkable feudal order. Russia, it seemed to them, was forever content to build a dam before the tide of progress. Society hovered on the threshold of the old world and a new post-feudal order seemed inevitable. "History moves too slowly", exclaimed the despairing co-assassin of Alexander II, Andrei Zhelyabov; "it needs a push".[2] When Kropotkin left for Siberia, he still believed in the possibility and usefulness of administrative reforms of the Tsarist autocracy. The five years that he spent there tell the story of his gradual disillusionment and final rejection of centralised administration and reform as a means of helping and improving the everyday life of the Russian peoples.

Kropotkin went first to Irkútsk as aide-de-camp to General Kúkel. The general was a man of remarkably radical opinions, who later only narrowly avoided arrest through implication in the escape of the great anarchist revolutionary, Michael Bakunin. Siberia's distance from Moscow, coupled with the fact that many misfits and critics of the autocracy had found a haven there, meant that enthusiasm for the reform process amongst Siberian settlers was very high. Kropotkin was immediately assigned to two reform committees; one on prison reform and the other on regional self-administration for Eastern Siberia. These areas of reform covered issues that he cared deeply about all his life. He put the whole of his youthful energy into researching and compiling his reports. His reports, however, like the work of so many others, simply collected dust on the desk of some official in the capital. Peter rapidly came to see the futility of such work in the face of administrative corruption and the abandonment of the reform process.

In 1863 Peter was given the chance to participate in an exploratory trip along the Amúr River. Although the trip was in part undertaken to provide the authorities with a picture of the previously uncharted sections of the lower Amúr, its more immediate purpose, was the delivery of some 40 barges of flour to a Russian

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[2]Frontispiece to David Footman, *Red Prelude: The Life of A. Zhelyabov,* London, 1955. This is to my mind the best written and most easily comprehensible introduction, history and analysis of the Nihilist movement.

settlement whose inhabitants were otherwise facing starvation. The expedition was far from successful, since nearly all the barges were wrecked in a sudden storm. Determined not to let the settlers starve, Kroptokin set off at once to inform the authorities of the disaster. He began the 2,000-mile journey back to Irkútsk in a rowing boat until he passed a passenger steamer which he commandeered before completing his journey through some of the wildest mountain tracks in Siberia. After a short rest at Irkútsk he completed the remaining 3,000 miles to Níjni Nóvgorod on horseback before catching a train to St. Petersberg. His experiences with the civil servants, whose professed expertise was in Siberian affairs, only served to strengthen his disgust with centralised authority. None of the functionaries he met had ever set foot in Siberia and, after asking a few pointless questions, passed on to chitter chatter about some frivolity. Peter was however rewarded for his heroism and returned to Irkútsk as attaché to the Governor-General of East Siberia for Cossack affairs. Despite his successes, Kropotkin was beginning to find military life completely unbearable and would probably have left the military that year. His taste for adventure, orienteering skills and proven courage had not, however, gone unnoticed by the authorities. He was asked if he would make a geographical expedition into Manchuria, which he was delighted to accept.

The object of the expedition was to find an overland route between Transbaikália and the Amúr province. This was in theory a difficult and dangerous mission as the Khingán Mountains, through which the Cossack cattle herders desired to find a path, was officially Chinese territory. Moreover, the area had only been penetrated previously by two Europeans. Disguising themselves as merchants they passed easily through the mountains and the expedition was completely successful. Their only brush with the Chinese authorities, although strengthening Kropotkin's distrust of centralised authority, was surprisingly comical. The ageing frontier guard was singularly unimpressed with Kropotkin's passport, consisting of a single sheet of stamped paper, and duly refused them entry. On presentation of an old copy of a bulky Moscow newspaper the old functionary hindered them no further.

Between 1864 and 1867, Kropotkin made several more expeditions to remote, inaccessible and often unexplored regions of Siberia. The results of these expeditions were warmly received for publication in influential geographic journals. A new career as a professional geographer became available to him:

> “The higher administration of Siberia was influenced by excellent intentions, and I can only repeat that, everything considered, it was far better, far more enlightened, and far more interested in the welfare of the country than the administration of any other province of Russia. But it was an administration,—a branch of the tree which had its root as St. Petersburg and that was quite sufficient to paralyse all its excellent intentions, and to make it interfere with all beginnings of local spontaneous life and progress. Whatever was started for the good to the country by local men was looked at with distrust, and was immediately paralysed by hosts of difficulties which came, not so much from the bad intentions of men,—men, as a rule, are better than institutions,—but simply because they belonged to a pyramidal, centralised administration. The years that I spent in Siberia taught me many lessons which I could hardly have learned elsewhere. I soon realised the absolute impossibility of doing anything really useful for the mass of the people by means of the administrative machinery. With this illusion I parted forever. Although I did not then formulate my observations in terms borrowed from party struggles. I may now say that I lost in Siberia whatever faith in state discipline I had cherished before. I was prepared to become an anarchist.”[3]

[3] Kropotkin, *Memoirs*, Part III, Section VII, passim.

For several years Kroptokin devoted himself almost exclusively to what he considered his "chief contribution to science":[4] his theories concerning the structure of the Asian continent. The work that he undertook during this period allowed him to gain the first true picture of the topography of Asia. This was an outstanding achievement and is a landmark in the history of physical geography. Accounts of his adventurous stories and the early results of his scientific findings were widely publicised and he was awarded a golden medallion for his great efforts and achievements.[5] In 1871 he was asked if he would participate in a geological expedition to Sweden and Finland, during which he received an offer from the Imperial Geographic Society to become its secretary. For someone under the age of 30, this was undoubtedly a great and rare offer indeed. Trouble, despair and poverty lay all around him. During the expedition he had a great deal of time to consider and reflect upon his life. What right, he asked, had he to enjoy the delights of scientific discovery, when the majority of those around him had barely enough food to live? He politely declined the offer.

Just as he had declined to join an influential regiment a decade earlier, Kropotkin, right at the point where he might justly have accepted financial reward and state patronage, decided instead that it was social, economic and political issues that should motivate the direction of his life. The death of his father as well as the communal uprising in France during 1871 gave Kropotkin both the freedom and the desire to travel to Europe and devote his life to the social-revolutionary movement. In 1872 he left Russia in order to investigate the International Workers Association in Switzerland. Switzerland had become the centre of revolutionary socialism after

[4] Ibid, Part V, Section I.

[5] Kropotkin’s Geological discoveries in Asia are described in *The Orography of Asia*, The Geographical Journal, UK, Vol 23, 1904, pages 176-207 and 331-61.

the suppression of the Paris Commune in 1871. Beyond this, there were large emigré populations of young Russians in the country at this time. Many of these were young Russian women, who, unable by law to study in their native country, had chosen, often against their parents' will, to pursue their intellectual ambitions in Europe. These people were called the Nihilists, not because they did not believe in anything at all, but rather because they did not believe in God or the oppressive and patriarchal traditions of their society. They most commonly studied subjects such as medicine and practical science, which they saw as useful to society and were secular in their orientation.[6]

Kropotkin went first to Zurich and then to Geneva. He was singularly unimpressed by the politicking of the Marxist-inspired groupings he found in these places and was advised to seek out the anarchists in the Jura Mountains. Here Kropotkin met many people but became especially impressed by a group of watchmakers at the small mountain village of Sonvillier. These free-artisans operated their little industry on the basis of workers' self-management within the context of a federation of village communes. The Jura federation was strongly influenced by the philosophy and personality of Bakunin, whose intellectual presence had drawn together a host of activists from numerous European countries. Kropotkin read every radical book and journal that he could lay his hand upon and became a convert to the basic ideas of social anarchism. The Russian secret service was keeping a close eye upon its dissident populations in the West and Kropotkin was only drawing attention to himself. Accordingly, he was persuaded that he would be far better employed trying to smuggle prohibited literature into Russia and trying to build a revolutionary

[6]See Meijer, J.M., Knowledge and Revolution: The Russian Colony in Zurich 1870-3, Assen: Van Gorcum, 1955.

movement in his native land. In the spring of 1872 Kropotkin arrived back in Russia with a heavy consignment of "unconditionally prohibited" literature.

Kropotkin joined an underground revolutionary grouping known as the Chaikovsky Circle. This had been founded in 1869 by Nicholas Chaikovsky and Sofia Perovskaya. Sofia Perovskaya, whom Kropotkin admired with an almost pious respect, became in many respects the alter ego of her friend Zhelyabov, whom she helped, with several others, to assassinate the Tsar nine years later. When Kropotkin joined the circle in 1872, however, it had only just ceased being a discussion group. Its members, rather than hatching terrorist plots, were just beginning to agitate directly among the peasants and workers. The group had up to this point confined itself to distributing literature, though in nineteenth century Russia, even Mill's liberal classic, *On Liberty*, was strictly prohibited by the censors. Kropotkin enthusiastically embraced the daring agitational tactic that involved directly lecturing to the workers and peasants.

During this period Kropotkin lived something of a double life. Using the cover of a respectable scientist he continued to work hard for the Russian Geographical Society, which had financed his last expeditions and to whom he owed considerable obligations. "Often," he relates in his *Memoirs*, "after dinner in a rich mansion, or even in the Winter Palace . . . I took a cab and hurried to a poor student's lodgings in a remote suburb . . . and went to meet my worker friends in some slum."[7] For over two years, assuming the cover name of Borodin, Kropotkin lectured to the workers and peasants, exhibiting, claims his comrade, Stepniak, his characteristic ability to deliver complicated ideas with a "clearness and simplicity that rendered them intelligible to the most uncultivated minds and excited the deepest interest

[7] Kropotkin, *Memoirs*, Part IV, Section XV.

among the workingmen."[8] Stepniak's observation was equally applicable to the police authorities, who began to enquire as to the real identity of the peasant Borodin. The pseudonym was nonetheless a remarkable success. By the middle of March 1874, Kropotkin, and another comrade called Serdukóff, were the only remaining members of this famous St. Petersburg circle who had not been arrested or forced to leave the city.

Kropotkin might well have evaded arrest if he had not chosen to stay behind with Serdukóff in order to recruit and train new members that would be capable of continuing the circle's activities in their absence. Kropotkin continued his scientific researches, delivering an influential and original thesis on the Ice Age to the Russian Geographic Society on the very eve of his arrest. Kropotkin was imprisoned in a section designated for political prisoners in the dreaded Peter-and-Paul fortress in early April. The walls were soundproofed. Because only six out of the 36 cells were occupied at this time, Kropotkin was forced to endure almost total silence. Writing materials were strictly forbidden for political prisoners. They were only obtainable by express permission of the Tsar himself. His brother, Alexander, upon hearing of Peter's arrest, immediately left Zurich for St. Petersburg. Alexander held a radical, but gradualist and less revolutionary position than Peter. His gradualism was a result of him becoming a disciple of the Russian philosophical-anthropologist, P. Lavrov, who also lived in exile in Switzerland.[9]

Alexander actively sought to gain the necessary permission for the writing materials so that Peter might complete his book on the Ice Age for the Geographical

[8]Stepniak (Kravchinskii), *Underground Russia*, London, 1883, pages 93-4.

[9]For an overview of Lavrov's thought and his relationship with Alexander Kropotkin, see Pomper, P., *Peter Lavrov and the Russian Revolutionary Movement*, Chicago: University of Chicago Press, 1972. See also "Alexander Kropotkin's Revolutionary Activities from 1872", Appendix D of Miller, M., *Kropotkin*, op. cit., pages 262-7.

Society. Alexander's successful efforts to gain the necessary permission for his brother raised considerable interest within international scientific circles. Peter's large two-volume study on the glacial period was a highly original hypothesis based upon his researches in Sweden and Finland. The entire work was written in the fortress. The first volume was published in 1876. Alexander would have been well advised to have left Russia but he insisted upon staying at Peter's side. He was arrested and sentenced to internal exile in North-East Siberia, for having what the authorities termed a "pernicious orientation".[10] Eleven years later, broken by the effects of exile, he committed suicide with a revolver—firing point blank into his head.

Until this time Peter had remained in remarkably good health, maintaining a strict routine of daily exercise and enthusiastically writing his book. He guessed that his brother had been arrested when he was informed that he was no longer available for the proof reading of his book. The psychological effects of at first being uncertain as to his brothers fate, combined with the rapid development of scurvy which he had first contracted in Siberia, severely weakened Peter's physical condition. Through the intervention of his sister, who obtained the services of a respected physician, Peter was committed to a military hospital. He was not expected to live. In the hospital Kropotkin recovered his health remarkably quickly, in fact too quickly, for the escape plan that he and his comrades on the outside were carefully preparing. The escape caused a sensation, as is shown from the following account in the *New Century Magazine* by a contemporary author and journalist:

> “In originality of conception and ingenuity of execution, the escape of Kropotkin from the Military Hospital in St. Petersburg is probably unparalleled in prison

[10]Miller, op cit., page 266.

> annals. Twelve conspirators outside of the prison took part in it, but not one of them was ever arrested or suspected, although many of them were subsequently banished to Siberia for other political offences. The escape was made in broad daylight, about five in the afternoon, in the presence of three armed soldiers, and with such novel accessories as cherries, opera-hats, a louse, violin music, a black mare and a microscope. The chances were at least ten to one that it would fail, notwithstanding the extraordinary ingenuity with which it was planned; but every device and stratagem worked perfectly, and the prisoner dined that night in the most fashionable restaurant in St. Petersburg while the entire police force of the capital was ransacking the city in search of him."[11]

Kropotkin left Russia by travelling north through Finland where he caught a boat to Sweden. In August 1876 he arrived in England under the assumed name of Levashov. He would not return to Russia until after the February Revolution of 1917.

Kropotkin made a scant living reviewing books for the British scientific journal *Nature*, but left for the Continent after a few months with the purpose of devoting his time to the work of the Jura Federation. The Federation, since the death of Bakunin, had declined. When Kropotkin arrived at La Chaux-de-Fonds (now its operational centre) it is clear that it was barely functioning. Shortly after he arrived, however, the earlier vitality of the Federation was temporarily resurrected. The Berne authorities had banned the flying of the Red Flag. Outraged by this restriction on their freedom, a contingent of some 40 people, including Kropotkin, sought to carry the flag to the town hall. Despite a large police presence, over 2,000 citizens, many of whom pledged their support, gathered at the town hall to welcome the demonstrators.

[11] Kennan, G., "The Escape of Prince Kropotkin", *New Century Magazine,* #7, Vol 62, 1912, page 246.

The period between 1878-1886 was a period of intense activism for Kropotkin. During these years he travelled widely throughout Western Europe, living for long periods in Switzerland and France. Kropotkin travelled to countries with strong anarchist movements such as Belgium and Spain, which influenced his thinking. He also participated in anarchist conferences in Switzerland, Germany and London.

This point in time also saw the beginning of Kropotkin's journalistic career. He contributed quite a number of articles to the *Bulletin of the Jura Federation of the IWA* [12]in the years 1876-7.

During the fall of 1878 Kropotkin met his future wife Sofia, a biology student who had previously lived in Siberia. They were married on the 8th October 1878. She became a supportive and caring wife who devoted herself to Peter and undoubtedly enabled him to live to an old age, well beyond that which might reasonably have been expected from the prolonged and considerable ill-health of his later years. In the fall of 1878 they were still young and busy people engaged in their own activities and rarely seeing one another.

Following the collapse of the *Bulletin*, the Jura Federation was left without a newspaper. Accordingly, in the following spring Kropotkin, with the help of two other comrades, produced 2000 copies of a new paper called *Le Révolté*, of which he assumed editorship. All of the 2000 copies were sold in a couple of days whereas previous papers of the Federation had only achieved a circulation of about 600. The Swiss authorities warned printers against publishing the paper and they were

[12] *Bulletin de la Federation Jurassienne de l'Association Internationale des Travailleurs* (Sonvilliers/Le Locle/La Chaux-de-Fonds), 1872-1878.

eventually forced to buy their own plant on credit. Impressive sales, however, soon allowed they to pay back the money to their creditors.

It is around this time that the anarchist communist idea was developed by Reclus, Kropotkin and others. In anarchist communism, as advocated by Reclus and Kropotkin, consumption was to be dictated by needs rather than according to one's contribution—as was the case under earlier collectivist or mutualist conceptions associated with Proudhon and Bakunin. Anarchist-communism conceived collectivism as being at best a stage along the road to anarchist-communism.

Non-territorial communities of interest are a key aspect of Reclus' and Kropotkin's conception of Anarchism. Despite often being credited with advocating small, isolated communities, both thinkers did "not to want to replace the authority of the state with the authority of the communes".[13] "We are not communalists/communists we are anarchists let us not forget that",[14] says Reclus, who had himself been a Paris Communard in 1871. Although isolated communal autonomism was rejected as means of revolution, Reclus and Kropotkin, did not think that a purely economic focus, especially upon trades unions, was enough. Although the importance of communal autonomy and worker's organisation were important, their anarchism was conceived as growing out the extended neighbourhood community linked by innumerable federations of interest groups in all fields of human inquiry, action and endeavour.

In 1880, due to Sofia's ill-health, the Kropotkins moved to Clarens where

[13] Cahm C., *Kropotkin and the Rise of Revolutionary Anarchism 1872-1886,* Oxford University Press, 1989, page 56.

[14] Ibid, page 51.

they lived with Reclus. Peter assisted Reclus in the compiling of his *Universal Geography*[15] and, is credited in providing assistance with volumes five and six dealing with Finland, European Russia, and Siberia. Thus, even at the height of his agitational career Kropotkin found the time to assist Reclus in what was, by any standards, an enormous undertaking. Reclus' monumental 19-volume geography of the Earth was the last ever such work written by a single man. Reclus became a lifelong friend of Kropotkin and their work covers much the same ground. Reclus' vision of anarchic harmony is more expansive including, for instance, passionate appeals to end the cruelty to children and to animals. In many places Reclus' rhetoric and notions of biological-egalitarianism bear a remarkable resemblance to ideas associated today with the so-called Deep Ecology Movement. Kropotkin never converted to vegetarianism and had a very much more human-centred approach to the Earth than that of Reclus.[16]

Reclus, like Kropotkin, is a landmark figure in ecology and is regarded as one of the founders of the idea (at least in its modern scientific sense) of the Earth as a self-regulating system. Whilst staying with Reclus, Kropotkin continued to write for *Le Révolté*, which had maintained its vigour and remarkable popularity. Soon the articles began being published as pamphlets in many different languages. Some of Kropotkin's best journalism was written at this time. It is outstanding for its freshness, directness and simplicity. *An Appeal to the Young*, reprinted as a pamphlet in 1881, was translated into 14 languages in Europe alone and was distributed worldwide. It is described by its English translator and early English Marxist,

[15]All 19 volumes of this great work have been translated into English.
[16] See, for example, Reclus' pamphlets *Vegetarianism* and *The Great Kinship.*

Hyndman, as "the best propagandist pamphlet that was ever penned."[17] Other articles from this period were collected together by Reclus and published in 1885 as Kropotkin's first political book, *Words of a Rebel.*

Early in 1881 six members of the "People's Will", including Kropotkin's female comrade Sofia Perovskaya, finally succeeded in assassinating Tsar Alexander II. When Kropotkin received the news he immediately commended their action in a special issue of *Le Révolté*.[18] Later, when Kropotkin heard the news of their brutal executions he published a small pamphlet condemning the action of the Russian authorities.[19] Although Kropotkin would have dearly liked to have returned to Russia, this would have been foolish. He was persuaded instead to attend an international anarchist conference in London, which, despite the presence of many celebrated revolutionaries, such as Chaikovsky, Malatesta and Louise Michel, failed to achieve a firm organisational base. On his return to Switzerland in August 1881 the authorities officially ordered Kropotkin's expulsion. This hardening of attitude on the part of the authorities was occasioned by his outspoken denouncement of the Russian executions earlier in the year.

Two of the most common misrepresentations of Kropotkin is that he was a peace-loving individual who thought that a new society could be created by non-violent co-operative means and, at the other extreme, that he, advocated terrorist plots and bomb-throwing as a means of furthering the anarchist cause. The founder of modern systems-ecology, Eugene Odum, for example, after noting some of Kropotkin’s important contributions to the development of ecological science, goes on

[17]Hyndman, H.M., *The Record of an Adventurous Life*, London: Macmillan, 1911, page 266.
[18]The special issue of *Le Révolté* was published on March 18, 1881.
[19]*Le Verité sur les Executions en Russie*, Geneva: Imp. Jurassienne, 1881.

to state that, like “Gandhi and Maritin Luther King”, Kropotkin “was a firm believer in non-violent solutions to human conflict.”[20] Kropotkin was no pacifist, as Odum implies. In fact, Kropotkin, had a brilliant military career before going over to the revolution, urged his comrades to carry revolvers to the Berne demonstration and did not hesitate to arm himself if he thought he was likely to encounter police violence.

He was expelled from Switzerland for producing a pamphlet praising the assassins of Tsar Alexander II[21], and at other times praised similar acts of individualistic terrorism by Solovieff[22] and Vera Zasulich. Whilst discussing Zasulich’s actions at the Lyon trial of 1883[23], Kropotkin states “I think that when a party, like the nihilists of Russia, finds itself in a position where it must either disappear, subside or answer violence with violence—then it has no cause to hesitate and must necessarily use violence.”[24] Kropotkin’s endorsement of such acts was however highly qualified. The unbelievable repression in Russia, Kropotkin (as well as many others) thought, had pushed the cream of Russia’s youth into political terrorism out of pure desperation. Outside of the particular context of Russia, unless such acts were motivated by a spontaneous act of revenge against a hated individual, or the like, Kropotkin generally thought them at best regretable, sometimes abhorrent, and as having a generally negative consequence in terms of state-repression and the public association of anarchism with individual violence and chaos.

[20] Odum E., *Ecology and our Endangered Life-Support Systems*, 2nd Ed., Massachusetts, Sinauer, 1993 page 178.

[21] *La Verite sur les executions en Russie*, Geneva, 1881(pamphlet).

[22] *Le Proces de Solovieff*, Geneva, 1879 (pamphlet).

[23] The trial is covered in Le Revolte, 20 January-3 February 1883.

[24] Cahm C., *Kropotkin and the Rise of Revolutionary Anarchism 1872-1886*, page 109.

At this time, Western European anarchists, inspired by acts of terrorism in Russia, an insurrectionist view of propaganda in Italy and the increasingly reformist and parliamentary direction of the labour movement, came to embrace the idea of '*Propaganda by the Deed*'. Kropotkin is often credited with founding or supporting this particular creed. It is also considered highly probable that he was the co-author of one of the earliest articles using the slogan as its title. The article appeared in the *Bulletin* in 1877[25], much later, in 1909, he strongly denied any association with it. Cahm analyses his criticisms of the slogan closer to the time this article was written and, convincingly argues that even at this early period, Kropotkin was very critical and disturbed by the concept and its consequences. At first 'Propaganda by the Deed' was a call to engage in inspiring action, such as that of the Berne demonstration, rather than restricting oneself to oral and written propaganda. As such it did not exclude collective acts of revolt. Soon however, it became associated with individualist and fairly indiscriminate acts of political violence. Kropotkin, Cahm shows many times over, disliked the idea of an act of political violence being undertaken as a publicity stunt. He found it inauthentic, unethical and profoundly disturbing. Kropotkin was only interested in "serious acts of revolts" not "dramatic gestures"[26] and did not believe that individualistic or small-group action could be a substitute for oral and written propaganda.[27] "For Kropotkin, the important point was that when individuals, outraged by the system, attempted to take the life of a man, they did so because he was a viper whom they hated, not because they wanted to make propaganda."[28]

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[25] La Propagande par le fait, Bulletin, August 5, 1877.
[26] Cahm C., *Kropotkin and the Rise of Revolutionary Anarchism 1872-1886*, page 103.
[27] Ibid, page 105.
[28] Ibid, page 110.

Kropotkin never subscribed to indiscriminate violence against the bourgeoisie or a narrow preoccupation with terrorist assaults on autocracy (which is republican not anarchist). Rather, Kropotkin advocated a broad approach where every possible opportunity was fully exploited for developing all sorts of revolutionary action, posters, newspapers etc.[29]. Although sympathetic to individualistic acts of *political* terrorism in his native Russia, which he regarded as genuine acts of revolt against repression, Kropotkin did not believe that individual acts of assassination could be any substitute for collective or popular revolutionary acts. Although Kropotkin showed a remarkably strong degree of sympathy and support for Perovskya's tsaricide of 1881 (he idolised Perovskaya—knowing her intimately through his earlier membership of the Chaikovky circle), Cahm suggests, that a careful reading of his 1881 pamphlet reveals that he wanted to pay tribute to her as great populist agitator and organiser of newspapers, meetings, groups.

Kropotkin insisted on the need for anti-capitalist economic direct action rather than political terrorism. Economic direct-action involving spontaneous and leaderless revolts as well as planned social-economic actions through organisations such as trades unions and communities, at both the local and international level. Kropotkin, especially after 1880 which saw the rise of a new militant trades unionism and a vogue in France for violent individualist illegalism, came to attach less and less significance to individualist acts of political terrorism.

With the coming of the Labour revolt in Lyon area of France he declared that the "period of simply attacking crowned heads was over, the workers were now attacking their real enemies, the economic oppressors."[30] The time had now come for

[29] Cahm C., *Kropotkin and the Rise of Revolutionary Anarchism 1872-1886*, page 276.
[30] Ibid, page 182.

“anarchists to direct their efforts into the economic field instead of the increasing preoccupation with dramatic action by individuals”.[31]

After their expulsion from Switzerland, the Kropotkins stayed in the French border town of Thonon for a couple of months to enable Sofia to complete her degree. It was not safe for them to remain too long in France and they returned to London where they were anything but happy—Peter describing his time in London as a "year of real exile".[32] There was little to interest Kropotkin in England at this time and, although continuing his agitational activities and working hard at his journalism, he recounts in his *Memoirs* how he and Sofia repeatedly said to one another "better a French prison than this grave".[33] In October 1882 the Kropotkins, depressed by the lack of revolutionary consciousness among the English workers, returned to Thonon. Here they were subject to continual harassment by both Russian spies and the local gendarmerie. As industrial action began to sweep Southern France—centred around Lyons—the police harassment became steadily more intense.

In December the police arrived to arrest Peter. The trial, which lasted from the 8-19th of January 1883, was by all accounts a farcical display of state-justice. Unable to prove that any of the terrorist acts anonymously committed during the Lyons unrest were attributable to either Kropotkin or any of the other 54 anarchists on trial, the judges sentenced Kropotkin along with many others to five years' imprisonment. The pretext for this was that they belonged to the International Workers' Association, an organisation which had long ceased to exist. Whilst the trial

[31] Cahm C., *Kropotkin and the Rise of Revolutionary Anarchism 1872-1886*, page 199.
[32] Kropotkin, *Memoirs,* Part VI, Section VI.
[33] Kropotkin, *Memoirs,* Part VI, Section VI.

proved to be an acute embarrassment for the French justice system, its usefulness in terms of the spread of anarchist propaganda is undoubted. All of the accused anarchists made long and eloquent speeches in the course of their defence, and many of these were immediately published in the major national newspapers.[34] Although Kropotkin was given preferential treatment as a "political prisoner", by the end of 1883, his health had seriously declined. A dangerous combination of malaria and scurvy led the March 1884 edition the English socialist paper *Justice* to claim that the "health of this vigorous agitator and friend of the people has suffered so severely from imprisonment that his death approaches".[35]

Help came quickly however. Sofia had abandoned her studies in Paris, which would have led to her Ph.D., in order to be at his side. Meanwhile, a huge petition was delivered to the French Government. This had been signed by a vast cross-section of British scientific and literary figures. By the time of his recovery this continued pressure upon the French government led to his release in January 1886. On release he went to Paris where he spent time investigating the market gardens just outside the city, an interest which he had developed while working in the prison. These organic forms of small-scale commercial horticulture later became an important aspect of his ecological-anarchist vision.

On the eve of the Kropotkins' departure for London, six weeks after his release, Peter delivered a farewell lecture to several thousand people in Paris entitled *The Place of Anarchism in Socialistic Evolution*. This has been published as a pamphlet in many languages but has never been anthologised in book form in English. It is, however, one of the finest of his shorter works in virtue of the fact that

[34]"The Trial of the Anarchists at Lyons, *Liberty,* Boston, II, 7, February 17, 1883. Contains an abridged version of Kropotkin's speech.

[35]*Justice: The Organ for Social Democracy,* Saturday, March 1, 1884.

it combines a lucid introduction to social-anarchism with a discussion of the anarchist approach to ethics, morality and social order.

Kropotkin's life up until this point can be roughly divided into three successive phases; military adventurer, professional geographer and anarchist agitator. Kropotkin's arrival in London, in 1886, represents a completely new phase of his life; that of scholar, theoretician and philosopher. This path was not chosen by him. Effectively banished from continental Europe he really had little choice but to continue his exile *quietly* in the British Isles. Nineteenth century Britain provided asylum for a large emigré community. Those Russians who were prepared to confine their activities to the pen and soapbox were left in peace by the authorities. Although Kropotkin did attend demonstrations shortly after arriving in Britain, he never fully recovered his health and was gradually forced to accept a more retiring lifestyle.

It was to be more than three decades before he could return to his native land. He used this time to combine the scattered insights of Fourier, Proudhon and Bakunin with the living ideas of Russian populism and European anarchism into a comprehensive social philosophy. His background as a professional natural and social scientist allowed him legitimately to extend these concepts into anthropology, biology and economics. In doing so he became one of the founders of modern environmental science and political ecology. A speaker of over 20 languages and able to write with a distinctive style in many European ones, combined with the fact that he was forced to earn a living from his pen, meant that his output was vast, his style remained popular and his influence was world-wide.

Since the Kropotkins' last visit to England there had been great resurgence of interest in social and labour issues. Peter began establishing a relationship with various radical political groupings. The most important personality he met at this time was William Morris. This remarkable English poet, designer, illustrator, utopian writer and sometime anarchist had just broken away from the Hyndman's Social Democratic Federation to form the more libertarian Socialist League. Morris' utopian writings are a mixture of a backward-looking, Pre-Raphaelitism and an impractically romantic notion of a future craft-based society that has turned its back on mass industrial culture. His political writings are more down-to-earth, involving searing analysis of capitalist society and a heartfelt plea for the workers of the world to unite, overthrow the ruling classes and self-manage healthful and useful labour for the good of all.[36] Morris wanted to recreate the craft-full spontaneity of high medievalism with its trade guilds, free cities and popular organisations whilst eliminating hierarchical and exploitative ideas and practices.

The Nihilist movement, which had nourished Kropotkin in his youth, was directed primarily to the peasants. It consisted of an appeal to the peasants to take control of their communal lands and trade networks and, through education and the self-introduction of modern scientific discoveries and technologies, on a small, local or village level, obtain the material benefits of the Enlightenment whilst avoiding the pain of mass industrialism and the development of a proletarian class. As a champion of the "scientific age", Kropotkin did not for one moment accept Morris' anti-machine stance, but his appreciation of the relative backwardness of his native Russia, his admiration for his art and poetry, and a deep personal interest in early medieval history resulted in Morris wielding a considerable intellectual influence over the style and direction of Kropotkin's later thought. The influence of Morris' medievalism is particularly noticeable in the central chapters of his seminal work, *Mutual Aid*.

[36] A recent study of Morris' socialist writings is McKercher, W., *Freedom and Authority*, Montréal Black Rose Books, 1989.

Kropotkin's thought does, however, differ considerably from that of Morris. Although the newspaper of the League, *The Commonweal,* published four of Kropotkin's earliest and most powerful articles, it is unlikely that the two men could have collaborated in the production of the newspaper. Instead, Kropotkin, in close association with Charlotte Wilson, began the important work of establishing *Freedom,*–one of the first English language journals devoted to social anarchism. Nonetheless, he continued to submit articles to its French counterpart, *Le Révolté.* This was a considerable effort, as at this time he was still recovering from prison and was emotionally devastated by news of his brother's suicide. The birth of their first and only daughter and his wife's subsequent ill-health, combined with the pressing need to earn a living from contributing to scientific journals such as *Nature* and reference works such as the *Encyclopaedia Britannica*, make this effort all the more remarkable.

In October 1886 the first edition of *Freedom* appeared. Throughout the autumn Kropotkin made extensive lecture tours in England and Scotland. These lectures continued throughout the following two years during which time he visited most of the major towns and cities, one lecture attracting upwards of 4000 persons. His first major attempt to elucidate a coherent philosophical account of social anarchism was published in *The Nineteenth Century Magazine* and later formed the basis of his influential pamphlet *Anarchist-Communism.*

His lecture tours included one trip to Paris where he cheekily delivered a speech entitled *Prisons and their Moral Influence upon Prisoners*. Although little is known about the trip, the authorities must have been far from friendly. Kropotkin did not attempt to enter France for nine years despite his passionate desire to live in exile there. Kropotkin, whose first job when he left school was to report and inspect

Siberia's prisons, later went on to write two books on conditions in Russian and French prisons. This brilliant little study on the detrimental effects of prisons on prisoners, society, as well as the guards condemned to working within their walls, anticipated much of the sociological criticisms of institutional life and bourgeois criminology in the post-World War II period.

Despite his frequent lecture tours (or more probably because of them), the Kropotkins were beginning to enjoy a rich domestic and social life in England. They were introduced, often by Morris, to many distinguished 19th century personalities who were curious to meet the famous anarchist prince. In fact it is hard to find many people, regardless of political divisions, that had not met or been in someway connected with Kropotkin during his long exile. Writers such as Ford Maddox Ford, Oscar Wilde and George Bernard Shaw, the Pre-Raphaelite artist, Rossetti, the famous Labour parliamentarian, Kier Hardie; the poet W.B. Yeats; and a veritable feast of other equally well known people befriended the Kropotkins, frequently visiting them at their small house on Sunday afternoons.

During his extensive tours of Britain he had a great deal of time to observe and investigate industrial and agricultural practices. He was particularly impressed by the allotment system which still exists in England to this day. In 1889, 1896 and 1903, he made special excursions to Guernsey to learn about its intensive horticultural systems under glass. This information, much of it extremely detailed and presented according to the exactitude demanded by modern economical science, was incorporated into his essays on economics which were published as the book *Fields, Factories and Workshops* in 1899. This book, which may be regarded as an early work on social ecology is similar in theme to E. F. Schumacher's famous book *Small Is Beautiful*.[37] Its overriding theme is to re-evaluate regional self-sufficiency and community life through taking advantage of appropriately scaled technology and modern communication facilities. Decentralisation of industry was to be complemented through the adoption of, what he terms in his book *The Conquest of Bread*, an “organic” approach to land-management and food production, within both an urban and rural context. His vision involves the creation of a more environmentally balanced country-city relationship.

At the same time Kropotkin was working on what proved to be his most influential and widely read book *Mutual Aid*. The book was primarily aimed at the crude social Darwinism of T.H. Huxley, who had interpreted natural selection in terms of continual, brutal and individualistic conflict. A remarkably persuasive interpretation, often maintained at a level of self-evident truth, and which has become a thoroughly integrated dimension of our popular scientific folklore. The presentation of the evidence for social co-operation amongst the animals is presented in a simple and polemical way that more than equals the rhetoric of his opponent. He examines numerous examples of animal co-operation and social life and concludes that mutual aid, in so far as it enables the development of intelligence and strength in unity, is an equally, if not more important means of survival than individualistic contest for scarce resources or mates. The popular and picturesque manner in which he presents his theories on mutual aid among the animals is still capable of convincing the uninformed reader of the faults of the standard "survival of the fittest" account of the evolution of life.

The sections that cover mutual aid amongst what he terms the "savages" and

[37] Schumacher, E.F., *Small is Beautiful: A Study of Economics as if People Mattered*, London: Blond and Briggs, 1973.

the "barbarians" are terribly dated. What he seeks to do is to address a racist and Victorian audience convinced that "uncivilised" people had any structured social life whatsoever; that before the Empire had kindly bestowed order, people simply rampaged around the jungle like the mythical man-eating gorillas of the sort that used to appear in popular books and magazines of the same period. In opposition to such overwhelming prejudice, Kropotkin attempts to show that, "stone-age" society was, in its way, more egalitarian, more humane and equally as complex as our social life today. The material is presented in a way that divides the social evolution of our species into specific stages. This is an approach which few anthropologists of the present day would be prepared to accept. Although modern and detailed assessments of indigenous cultures have largely confirmed the essential thrust of his arguments, these sections of *Mutual Aid* are not well written. Reclus' descriptions of the ecology and customs of indigenous peoples, in his *Universal Geography* and elsewhere, are incomparably better than those of Kropotkin. Reclus' genius in this respect was acknowledged by Kropotkin in his Obituary.[38]

The sections on mutual aid in the medieval city, on the other hand, are well-written. They have done much to counter the mistaken idea that the Middle Ages was an unsophisticated and brutal era dominated by warring kings. His writings on the medieval city influenced many subsequent writers on the history and theory of urban life and evolution. Of special note in this respect, is Lewis Mumford, a disciple of Kropotkin, whose many books have been widely acclaimed by numerous experts upon the subject of urban evolution.

Mutual Aid, although never mentioning the word "anarchism", has remained a cornerstone of social-anarchist theory. This is because it gives an account of the

[38]"Elisée Reclus", *The Geographical Journal,* September, 1905, and *Freedom,* August, 1905.

social evolution of humanity as well as raising the question: If we were social before we were human, why should we need a state to organise society for us?

Kropotkin was always forced to earn a living from his writing and during the time that he composed his most famous works he undertook a considerable amount of popular scientific work and journalism to supplement his income. This body of work represents in itself a substantial achievement. Kropotkin took over the *Recent Science* column of the *Nineteenth Century Journal* from Huxley, his most famous intellectual adversary. Over a period of nearly a decade (1892-1900), Kropotkin contributed around 20 long articles, all entitled *Recent Science*. These articles were subdivided into two-to-four shorter articles (but all of which, by the standards of scientific journalism are substantial pieces of work of around five-seven pages long with no graphics), most of which are untitled. Kropotkin made his living from his pen, but although these articles were primarily written for financial gain, the breadth and depth of their subject matter reveals a scientific mind ever hungry for more knowledge. They are in my opinion remarkable for their detailed research. Judging from the footnotes, Kropotkin read the premier scientific journals in all major European languages as well as a great many scientific books. He continually kept abreast of scientific developments, and in characteristically clear articles he conveyed complex scientific concepts and discoveries to his late 19th century English speaking audience.[39]

Kropotkin also contributed scores of articles to three editions of the Encyclopaedia Britanica (1887-1911) on the geography of considerably more than one sixth of the land area of the Earth (Most of the former Soviet Empire–European

[39] These articles and those of the Encyclopedia Britanica and The Geographical Journal are listed in the separate bibliography upon Kropotkin's scientific work.

Russia, Baltic states, Central Asia and Siberia, but additionally, Finland, Poland and Mongolia). His broad interests in geology, botany, zoology and industrial development resulted in the longer articles becoming a sort of condensed bio-geographies of vast areas of the Earth: The distribution of fauna, flora climate, geo-physiography, etc., of each region inclusive of the ethnic history and present agricultural and industrial activities of its human inhabitants. For lesser reference works, such as Chambers's, Kropotkin wrote articles covering the whole of Asia (two-fifths of total landmass of the Earth) as well as European Russia.

Though Kropotkin is often thought of as one of the founders of modern environmentalism, this is not always easy to substantiate upon the basis of his political, social and economic works. These reference articles, however, clearly exhibit a deep environmental sensibility–including information, for example, upon the state of forests, over-exploitation of natural resources and the extinction of animals and ecosystems.

Kropotkin, from almost the very first issue of *The Geographical Journal* (of the Royal Geographical Society in London), continually contributed articles on areas of special expertise or interest, for instance, on Asian and Siberian geology, geography, paleo-ecology, zoology and botany and explorations/expeditions to/of these regions.

Orography and glaciation were also of particular interest to him. The most substantial and important work contained published in this journal is a very long article (60 pages, published in two parts): *The Orography of Asia*. This work together with a French article upon the Orography of Siberia were brought together in his later geological and geo-botanical book (119 pages) *Orographie de la Siberie avec un apercu de l'orgraphie de l'Asie* (Institut Geographique de Bruxelles, 1904). In this book, Kropotkin presents his geological discoveries made in his youth and updates them in the light of more recent discoveries. Kropotkin's concept of orography was very broad and an inherently ecological one. The description of the various ranges is not a one-dimensional, bare-structural or geological description, but also includes many detailed and quite charming passages concerning the vegetation, climate etc., as well as the distribution and impact of human settlement. Indeed, a very much shorter version of this work published in the Popular Science Monthly was entitled, *The Geology and Geo-botany of Asia*. Thus Kropotkin was not simply a geologist but a biogeographer as well.

Kropotkin is remembered in scientific circles as the foremost Asian geologist and geographer of his time. In this respect, his pioneering studies of Siberian and Scandinavian geology will always be remembered in the history of the Earth Sciences. It is often suggested that Kropotkin, after turning to politics, and in consequence, becoming exiled to Western Europe, no longer pursued a scientific career. However, his 40 year exile, although preventing further explorations of Siberia, did not prevent him from producing a substantial body of scientific journalism, a large number of articles for professional scientific journals, as well as scores of articles for standard works of reference. Thus Kropotkin, though unable to make any more original contributions to geology, did not give up his scientific career, but fully contributed, throughout his life, to both the advancement and dissemination of scientific ideas and knowledge. This thesis attempts to give equal consideration to his scientific as well as political philosophy.

In addition to his political and scientific work, Kropotkin also had a journalistic career in the establishment press. Many of his letters were published in *The Times* of London and he wrote numerous articles and letters for the *Manchester*

Guardian, the *Newcastle Daily Chronicle*, *The Forum*, etc., over a period of many, many years.[40]

Mutual Aid, *Fields, Factories & Workshops* and his other major works did not begin to appear until the end of the century. While he was working on them he did not neglect his anarchist journalism. He continued to contribute prolifically to *Freedom* and *la Révolte* (renamed in 1887 because of a police ban on the previous title of *Le Révolté*) simultaneously writing a revolutionary anarchist program for both English and French speakers. The first, although sensitive to British issues, is an inferior work to its French sister, and was not published in book form until 1988.[41] *The Conquest of Bread* which was published in Paris, in 1892, is a masterpiece. The great French novelist Emile Zola described the book as a "true poem".[42] The book did not, however, merely impress and titillate the imaginations of the literary élite. Written in simple and clear language, it was divided into easily digestible segments that could be read out to groups of illiterate peasants. *The Conquest of Bread* was used in exactly this way to very great effect in Spain and it had marked effect on development of anarchism in the countryside during the revolution of 1936-39. The sections on the need to provide attractive and diverse work and a stress on providing goods to people according to their needs rather than their deeds, although owing much to the insights of Fourier, is eloquent and forcibly stated. The section on agriculture, again, owes much to Fourier and stresses the need for communal experimentation with new forms of organic horticulture. It incorporates in a succinct, but powerfully persuasive thesis, much of the information which was later expanded

[40] I have not even attempted to compile a bibliography of this work.
[41] *Act for Yourselves!*, ed. N. Walter and H. Becker. Articles from *Freedom*, 1886-1907, Freedom Press, U.K., 1988.
[42] Quoted in Ely, R., "Pince Kropotkin", *Atlantic Monthly*, September 1898, page 346.

upon in *Fields, Factories and Workshops*. The wide variety of organic and communal horticultural ventures undertaken by the peasants during the course of the Spanish Revolution is directly attributable to the practical, optimistic and inspirational tenor of this truly great classic of social anarchist propaganda.

When Kropotkin began his exile from continental Europe, in Britain he had witnessed a growing militancy among the workers which culminated in the Great Dock Strike of 1889. Although Kropotkin had considerable sympathy for the strike he has always been highly critical of British trades unionism and, some of his earliest journalism for the *Bulletin* and *Rebel* contain scathing criticisms. The formation of the British trades union congress in 1871 had resulted in a situation where "on the dozen occasions when the parliamentary committee of Congress would visit a minister, they would 'exchange compliments with each other on their good manners and separate mutually enchanted.'"[43] Kropotkin thought that the conciliatory, reformist, pacifistic, parliamentary, nature of British trades unionism was persuading the more youthful labour movement in other parts of Europe to adopt similar methods. He feared that the trades union movements of the continent would "develop along the lines of British trades unionism", with its emphasis on reducing working hours and wage increases. Although Kropotkin advocated proto-syndicalist methods he was not fundamentally anti-unionist. It was British trades unionism with which he was particularly disgusted, because, unlike its counterparts in other parts of Europe, it had long since leaned towards a regulatory, reformist and an essentially non-revolutionary orientation. The British workers, after a brief period of unrest, seemed satisfied with piecemeal improvements in wages and conditions. They had

[43] Cahm C., *Kropotkin and the Rise of Revolutionary Anarchism 1872-1886*, page 235.

little interest in the sweeping social revolution envisioned by Kropotkin in *The Conquest of Bread*. The book, using the communal uprising of 1871 as its starting point, goes on to predict a second French Revolution: a social revolution that will re-communalise the 30,000 villages, towns and cities of France and herald the development of a Europe-wide movement. The postal and transport workers of each region or nation would learn to integrate their activities to facilitate the development of complex inter-communal federations through providing the transport of people, goods, services and information on a non-profit basis for the benefit of all.

The establishment of an Independent Labour Party in 1893 was immediately popular with the British labour movement which had become dominated by reformist and state-supervised notions of gradual social change by parliamentary means. Although the British Anarchist movement had certain pockets of influence, such as in London's East End district, it had little support. The circulation of *Freedom* was exceedingly small. Although Kropotkin's later books supported his political goals they only very rarely, if ever, made explicit reference to anarchism. *The Conquest of Bread*, the one book that might have been influential if it had been adapted to an English audience, was not translated or published in English until 1906. Kropotkin was regarded, in Britain, as being first and foremost a scholar and the author of learned scientific, historical and economic works. Indeed, being of aristocratic background he was treated with great respect by members of the English bourgeoisie.

In 1896 Kropotkin was invited by French comrades to deliver a lecture to them in Paris in order to raise funds for *Les Temps Nouveaux*, the paper which replaced *La Révolte* following its suppression two years earlier. Kropotkin was turned back by the authorities upon his arrival in France and his long lecture, *The State: Its Historic Role*, was never delivered. It was, however, published as a pamphlet in both English and French shortly afterwards and undoubtedly remains the finest of his shorter works. It is essentially a work of philosophical-anthropology. It is dextrous and masterful, and has little in common with the crude analysis exhibited in the central sections of *Mutual Aid.* The development of hierarchies in stateless societies, by virtue of the old dominating the young or through religious manipulations, are analysed in some detail. Rather than presenting us with a fixed and rigid account of societal evolution, civilisations rise and fall in exact relation to the bureaucratisation and alienation of the élite from the people.

European and colonial history is portrayed in dramatic terms as a continual battle between the forces of the free community and independent region against the brutalising legacy of Roman imperialism. There will always be conflict, he assures us, until free-community has defeated the forces of capital and state. However triumphant state-civilisation might appear in the short term, all of them have decayed through indolence and/or militaristic misadventure. In order to achieve genuine social progress, he concludes, it will be necessary to break this never-ending cycle of the rise and fall of the state and initiate new social forms based upon regional self-government and communal autonomy.

In 1897 Kropotkin was presented with a chance to escape from the frustration of his exile in Britain when the Canadian economist James Mavor invited him to stay in Toronto. Kroptokin delivered three papers concerning the geology of Finland and Asia to the 67th meeting of the British Association for the Advancement of Science at the University of Toronto, where Mavor was a professor. Apart from travelling right across Canada on the Pacific railway line, Kropotkin also found time to investigate the experimental farms of the Mennonite communities of the North-West and

Manitoba. In a delightful article entitled *Some of the Resources of Canada*,[44] he devotes many pages to discussing how they had prospered through communally working environmentally sensitive small-scale farms. He was, however, sharply critical of the religious, semi-monastic and avowedly hierarchical aspects of these self-sufficient and independent rural communities. Such communities, he concluded, left little room for individual self-expression.

His observations concerning small-scale communal experiments undoubtedly prompted the writing of an important, and much neglected speech called *Communism And Anarchy*,[45] which was written for the aborted Paris Anarchist Conference of 1900. In this article Kropotkin produces a score of closely reasoned arguments as to why small-scale communalist experiments artificially constructed between relative strangers are always doomed to last but a short while, and, when they do so last longer, it is because they have relied upon a unifying personality, a dogmatic hierarchical or religious structure. It is a pity that the neo-Kropotkinites of the "swinging sixties" assumed that experimental adventures in the wilderness, nearly all of which resulted in failure, could achieve anything of lasting significance in the construction of a viable anarchist society. Communal experimentalism has a long and unhappy history and Kroptokin never assumed that genuine social change could emerge outside the context of the organically rooted human community which had a multi-generational attachment to the area which they inhabited.

From Canada Kropotkin went briefly to the United States giving numerous

[44] *Nineteenth Century Magazine*, London, March 1898, pages 494-514.

[45] *Freedom*, London, July and August 1901, This article, along with other related articles has recently been published in Purchase (Ed) *Small Communal Experiments and Why They Fail*, Jura Media, Sydney, 1997.

lectures on the Eastern seaboard. One particular speech delivered shortly after his return, entitled *The Development of Trades-Unionism*,[46] is particularly noteworthy. It provides a comparison between the trade guilds of the medieval commune with modern trades-unionism and outlines a brief but stimulating history of the I.W.A. Kropotkin has all too frequently, in recent years, been depicted as having rejected syndicalism.[47] Although Kropotkin through his experience with British and French trades unions became steadily more cautious of the organised union movement, especially with the collapse of the 1906 general strike in Russia, there is no evidence he considered that a post-revolutionary society could be brought about or sustained in the absence of large, inter-communal labour federations. *The Development of Trades Unionism* is alluded to in Rudolf Rocker's syndicalist classic Anarcho-Syndicalism, and influenced Rocker's conception of the place of industrial self-management in regard to revolutionary victory and the post-revolutionary reconstruction of anarchist society.

Another remarkable lecture, *Anarchism: Its Philosophy and Ideal*, was composed around this period and delivered to his American audience. In this, the philosophically most penetrating of all of Kropotkin works, he expounds a theory of the self- organisation of matter and paints a picture of evolution as having been a self-organisation of life from the simple to the complex. Order is not seen as something static and unchangeable but as a dynamic and ever changing equilibrium in which a multitude of forces compete with and complete one another in the formation of enduring but ever-fluid stability. These themes have only recently been

[46] *Freedom*, London, March 1898.

[47] See my recent polemic with Murray Bookchin in *Deep Ecology and Anarchism*, London, Freedom Press, 1993. See also Kropotkin's article *Anarchism and Syndicalism*, Freedom, August and September 1912.

rediscovered by the environmental movement as well as by modern chaos and complexity theorists.

Kropotkin's tour was also remarkable in other respects. Firstly, it was a great financial success and secondly, with regard to the part he was able to play in the resettlement in Canada of the Dukhobor peasant communities. These persecuted people, who were similar, but possessed a more libertarian outlook than the Mennonites, had fled Russia for Cyprus. They were experiencing hardship until Kropotkin was requested by them to intervene on their behalf.[48] In addition to this Kropotkin was commissioned by the tour's organiser to publish his *Memoirs* serially in the American journal *The Atlantic Monthly*. These articles were later expanded into book form and published in 1899. The book masterfully tells the tale of his own life up until the time of the beginning of his exile in Britain, and as such represents a key primary authority on the history of the Russian Nihilist movement.

In 1901 Kropotkin undertook another exhaustive tour of the U.S.A. giving lectures on Russian literature to 4000-5000 people. After fulfilling his contractual obligations he managed to arrange a good number of meetings in working class districts. On his return he suffered a heart attack which, although not causing lasting disability, led him to take up a much more retiring life-style. He spent a great deal of time at English coastal resorts in the winter and, as the Continental authorities relaxed their attitude closer towards the outbreak of World War I, at Italian and French ones as well. Kropotkin was very depressed during these years. He had always disliked Britain and only through force of circumstance had ever become resigned to residing there. The reformist attitude of the British Labour movement

[48] See Mavor, James, *My Windows on the Street of the World,* 2 vols., London and Toronto, J.M. Dent, 1923, II, Ch.XXX, pages 91-106.

simply drove him to despair. In 1902 he complained of the "misery of being the most permanent emigrés,"[49] and later, in 1903, he angrily wrote to a confidant in Paris: "such gloom, this London; I passionately detest this English exile".[50]

Throughout 1902, however, industrial and rural unrest in Russia began to divert Kropotkin's attention eastwards. The spontaneous, though organised, revolt of workers and peasants mirrored, Kropotkin believed, the early stages of the French Revolution. Kropotkin, in his later years, came to see the French Revolution as a kind of prototype for all the European revolutions—the forthcoming Russian one included. At this period though, he was simply heartened by what he saw as a "revival of the pure Labour movement," free from the shackles of party politics, constitutionalism and social democratic reformism.[51] The unrest of 1902 soon increased the strength of the small anarchist groups scattered around Russia.

The following year Kropotkin was asked if he would help with the production of a Russian-language paper by a Geneva-based press which had been printing and distributing the writings of Bakunin and Kropotkin in Russia for some time. Kropotkin had up to this point thought that emigré newspapers had little practical value. But as a stream of young revolutionaries began to enter Western Europe with up to date news and a network for transporting and distributing propaganda in Russia, the production of such a paper became a necessity. The collapse of western Europe's revolutionary impetus was, he believed, almost entirely due to the pernicious influence of Marxist teaching and organisation in both its "revolutionary"

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[49] Letter from Kropotkin to J. Guillaume, December 23 1903, quoted in Miller, *Kropotkin,* page 199.

[50] Letter from Kroptotkin to Marie Goldsmith, October 28 1903, quoted in Miller, ibid, page 169.

[51] Letter from Kropotkin to Marie Goldsmith, December 12 1902, quoted in Miller, ibid, page 206.

and "parliamentary form".[52] It was important, he felt, to propagate anarchist ideas at the preliminary stages of the revolution. The first edition of *Khleb i Volia (Bread & Freedom)* appeared in 1903 and it lasted until the end of 1905. Although many editions of the paper ended up in the hands of Russian emigrés in the U.S.A. and elsewhere, it had a considerable influence within Russia. For several years afterwards, their rivals in the revolutionary struggles called the anarchists the "Khlebovoltsi".[53]

Soon after the outbreak of the unsuccessful 1905 revolution in Russia Kropotkin attended a meeting in Paris devoted to Russian affairs. The emergence of worker-managed soviets as a vehicle of organised revolutionary struggle was a new development that had not been seen in the unrest in Russia three years earlier. There were strong disagreements over the significance of the Soviets, which were destined to play a predominant role in the successful revolution of 1917. Kropotkin, who later came to deplore acts of individual terrorism, saw the soviets, and the syndicalists in general, as a method of avoiding such tactics. He stressed, however that they should not ignore the rural masses and wisely and prophetically maintained that: "One may enter the Soviets, but certainly only as far as the Soviets are organs of the struggle against the bourgeoisie and the state, and not organs of authority".[54]

Kropotkin was now in his sixties and in frail health and his friends became very worried when he began to take up regular rifle practice in preparation for his

[52] For his analysis of European Social Democracy, see: "1887-1907: Glimpses into the Labor movement in this Country", *Freedom,* Octaber 1907; "Politics and Socialism", *Freedom,* February-May 1903, and "The Coming Revival of Socialism", *Freedom,* August-November 1903 and Feburary-March 1904.

[53]Woodcock, George, and Avakumovic, Ivan, *The Anarchist Prince: A Biographical Study of Peter Kropotkin,* London, Boardman, 1950, page 365.

[54]The accounts of this meeting although not contradictory are somewhat garbled; see Miller, op. cit., page 212 and Woodcock, ibid, page 362-63.

proposed return to Russia. The revolutionary tide, however, soon settled and by the middle of 1906 it had almost vanished. The course of events still remained uncertain. In two speeches, later reprinted as a pamphlet entitled the *Russian Revolution and Anarchism*, Kropotkin compares the European revolutions of 1789 and 1848 with that of Russia and concludes that they bear a remarkable resemblance. Hence, he asserts, it is necessary to avoid the mistakes of the great French Revolution which had allowed the communal land and property of the peasants to fall into the hands of private individuals. Nor, on the other hand, should the land be allowed to fall into the hands of some centralised assembly or state ministry as the state-communists and republicans wished. The land must go directly to the peasants, the organisation of the factories and railways must remain under the direct control of the workers. In the second speech Kropotkin, pointing to the success of the Russian general strike in 1905 and the accomplishments of the workers' organisations in Spain, urged his audience to actively participate in the trade-union movement in Russia.

By 1907 it was obvious that the revolution had failed. The workers and peasants who had previously been fooled into accepting the Tsar's reformist manifesto seemed unable to regain the revolutionary impetus. The lesson of 1906-7, Kropotkin claimed, was that "constitutional rights are worth nothing unless the people, even at the price of blood, change the paper concessions into real concessions—unless the people themselves extend their rights by beginning the reconstruction of the whole of society on the principles of communal independence".[55]

[55]"Enough of Illusions", *Freedom*, Aug. 1907. A version of "Assez d'Illusion", *Les Temps Nouveaux*, July 1907.

In the years following the failure of the revolution Kropotkin continued to produce long and short works of great quality. Works that are particularly noteworthy from this period of his life are the compact little article *Anarchism* that was commissioned for the 11th edition of the *Encyclopaedia Britannica,* and his monumental history, *The Great French Revolution.*

The rise of French Syndicalism, up until the outbreak of World War I, also provided a new basis for the development of revolutionary unionism. Kropotkin never opposed syndicalism, as an important means of achieving anarchism, but—"disliked the vision of a society narrowly based on worker's organisation".[56] "If syndicalism is taken up as the main and sole object of propaganda, then things are indeed bad."[57] In several letters and some articles Kropotkin indicates that he did not "associate anarchism with syndicalism"—but thought that revolutionary syndicalism and direct actionism represented a "revival of the great movement of the anti-authoritarian international".[58] Similar viewpoints are expressed in a later article *Syndicalism and Anarchism*[59] (recently republished[60]) where he again argues that

[56] Cahm C., *Kropotkin and the Rise of Revolutionary Anarchism 1872-1886*, page 269.

[57] Letter to Grave July 3 1902, quoted in Miller, op. Cit., page 177.

[58] Cahm C., *Kropotkin and the Rise of Revolutionary Anarchism 1872-1886*, page 268-9.

[59] *Syndicalism and Anarchism*, Freedom July and August 1912. Also available in Russian in Maximof (ed) *P. A. Kropokin I ego uchenie,* Chicago 1931(Maximoff's little study of Kropotkin's syndicalism is contained on pages 99-121). Other important *published* article by Kropokin on syndicalism not covered in Cahm's study include Kropotkin's *Les Anarchistes et les Syndicats*, Les Temps nouveaux, May 25 1907. This article was subsequently published as an 11 page pamphlet in German, *Syndiklismus und Anarchismus,* Der Syndikalist, Berlin 1908. Judging by the publication details the following article by Kropotkin is most probably also worth checking out, *Le Development des idees anarchistes*, in Encyclpedie du Mouvement Syndicaliste, no. 5, May 1912. Max Netlau republished a significant body of material on Kropotkin's syndicalism in Spanish in La Revista Blanca (Barcelona) in several articles in the winter 1933-34. In addition to the letters to J. Grave (published in Russian, see below) there are a few unpublished letters to G Herzig concerning syndicalism. More significantly there is also the voluminous exchange of correspondence, the 'great debate', between Guillaume and Kropotkin upon anarchism and syndicalism, some of which has been variously published, but demands considerably more scholarship. Kropotkin was against Guillaume's involvement with the CGT because of he believed it had elements orientating it towards reformism. The Grave correspondence and some of the Guillaume correspondence relating to the debate have been translated and published in Russian in Nettlau (Ed.) *probuzhdenie,* no. 15 (1931) pages 7-14

syndicalism was the revival of an authentic revolutionary unionism identical to that of the workers international, such as had existed prior to trade-union involvement with parliamentary socialism. In a letter to Bertoni, in March 1914, Kroptkin wrote "The syndicat is absolutely necessary. It is the only form of worker's grouping which permits the direct struggle to be maintained against capital without falling into parliamentarianism."[61].

The prominent Italian anarchist, Malatesta, thought that the anarcho-syndicalists were turning a means into an aim. Like Malatesta, Kropotkin, saw syndicalism as one means of achieving a much broader conception of anarchist society. Reclus was much more sceptical of the value of trades-unions than Kropotkin, but like Kropotkin structured his vision around the local urban and agricultural community not the territorial commune. This is today sometimes referred to as the extended neighbourhood model. Communities were to be based upon 'free association of individuals' and interest-related federations. Their view of anarchist society is one which is not narrowly structured around the workplace or industrial activities as envisioned by extreme syndicalist visions of future society. This does not however amount to a rejection of Syndicalism, as some people have claimed. Kropotkin believed in the importance of revolutionary unionism, but did not see it as an end in itself, but as part of a much broader vision and range of methods for social transformation.

(Grave) and 75-164 (Guillaume). All in all, a complete picture of Kropotkin's thinking upon syndicalism cannot be arrived at without considerable research.

[60]*Syndicalism and Anarchism,* Rebel Worker, Sydney Australia, Part I August-September 1999 the second part in a later issue—contact publisher for details.

See also my covering/introductory article on page 14 in the June-July 1999 edition of Rebel Worker.

[61] Cahm C., *Kropotkin and the Rise of Revolutionary Anarchism 1872-1886*, page 269.

In 1914 began the outbreak of world war, rather than world revolution. It also caused Kropotkin to suffer a period of estrangement from the anarchist movement that lasted until the triumph of the Bolshevik dictatorship in 1917. Kropotkin thought that the pacifist, anti-militarist standpoint and response of many of his fellow anarchists to German militaristic aggression completely impractical. Kropotkin, like Bakunin, was a man of action and never underestimated the importance that the very real and bloody ethnographic conflicts that still, unfortunately, continue in Europe to this day, might have on the eventual outcome of the World Revolution. There was no use talking piously about anti-militarism when the German army was threatening to bring all of Europe under German imperial rule. He believed that if the German army was triumphant the European and World Revolution would suffer an enormous setback. Kropotkin never changed his opinions on the root causes of war in general. His long article *Modern Wars and Capitalism,* serialised in *Freedom* during 1913, does not vary significantly from the views expressed in some of his earliest writings upon the subject (see the chapter entitled *War* in his first political book, *Words of a Rebel).*

Wars, Kropotkin believed, were the necessary result of the need for capital to expand into new markets, a radical position which, to take an example from the immediate present day, is sadly contradicted by the Serbian attempt to "ethnically cleanse" the Balkans. It is nationalism, and not just capitalism which lies at the *root* of many European wars and conflicts to this very day.[62]

Kropotkin never really appreciated that nationalism and not just national or state governments, might be a perverse force in its own right. His strong distrust of

[62] There is not space to discuss this issue in further depth. However on the subject of nationalism, one cannot go past Rudolf Rocker's masterpiece, *Nationalism and Culture*, first published in the 1930's but reprinted by Michael E. Coughlin, St Paul, Minnesota, 1978. This book was highly praised by Albert Einstein and Bertrand Russel.

the German people was coupled with frequent premonitions about the inevitability of a Franco-German war. As early as 1896, claims the famous German Anarcho-Syndicalist, Rudolf Rocker, Kroptotkin expressed the view that the Kaiser's government "was working in a direction which made war inevitable".[63] Such fears were not, however, openly expressed by him until 1899 when he published a long and damning article entitled *Caesarism*, in which he felt compelled to warn both France and England about how the "German Empire is only awaiting a favourable opportunity to wrest new provinces from us and to dismember France".[64] Kropotkin sincerely believed that the German people posed a real threat to European progress. In 1913, in another conversation recorded by Rocker, he conjectured that in the absence of European revolution, England and France would inevitably be drawn into a second and terrible war with Germany:

> “If Germany wins the war she will be for a long time the undisputed dictator of Europe. Her rulers will squeeze all they can out of the other countries, to make good her losses quickly. If Germany loses the wars she will be a problem to the victors, and the problem may not be solved without a European revolution. If Germany is broken up by the victors, it will create an irredenta that will give Europe no peace. The only hope is that a new movement may come from a defeated Germany. But such movements come only if the conditions exist in the minds of the people, and I am afraid they do not exist among the German people. If the Germans are defeated they will brood over their wounded national pride rather than want to listen to the voices of reason.”[65]

Given the historical development of Nazi Germany out of an embittered nationalism of a vanquished people, one can in the light of Rocker's words feel

[63]Rudolf Rocker, *The London Years*, London: Robert Anscombe, 1956, page 148.
[64]"Caesarism" Part III, *Freedom*, London, June 1899.
[65]Rudolf Rocker, op. cit., page 151.

inclined to retrospectively excuse his pro-war stand. Perhaps more than any other anarchist of his time he realised that the social forces which had been developing in Germany represented a terrible and formidable barrier to European peace and progress.

The rise of Fascism was not, however, a uniquely German phenomenon. The holocaust was a result of nationalism and racism of which Kropotkin during this period was also guilty. The majority of his comrades could see little but pointless slaughter in the war. Their lack of sympathy with his position rapidly turned to dismay as one of their most beloved and respected personalities of the anarchist movement indulged himself in the most reckless jingoism. The Germans, wrote Kropotkin, were an "army of Huns", an inhuman and savage horde that would have to be fought by all available means at the allies' disposal.[66] With the exception of a few friends, the anarchist movement at this period, painfully and regretfully, had to abandon Kropotkin.

During these years, Kropotkin was in the process of producing another major work on biology, in the areas of speciation and inheritance. Although Kropotkin made no original contributions to these subject areas, the central ideas of *Evolution and Environment*, the ‘direct action of environment’ and ‘the inheritance of acquired characters’, although not taken seriously for most of the twentieth century, have in recent years come to be much more positively evaluated. More generally, what is now called genetics is not an apolitical issue. In fact control of genetic technology and its products is at the very forefront of contemporary political debate surrounding science, capitalism and exploitation. It is not without significance that Kropotkin

[66]Letter to Jean Grave quoted in Miller, *Kropotkin*, page 225.

rejected centralised, hierarchical and uni-dimensional approaches to genetics and developmental biology.

During 1916 Kropotkin underwent surgery and was confined to a wheelchair for some time. Now in his seventies and in his fortieth year of exile, Kropotkin, whom Oscar Wilde had described as "living one of the most perfectly fulfilled lives",[67] seemed destined uselessly to while away his few remaining years on the English south coast. In February 1917, however, the Russian people finally succeeded in overturning the tsarist autocracy. The Kropotkins were of course overjoyed, arriving by train in St. Petersburg in June. As the train drew into the station, a crowd of 60,000 people, which had assembled in order to capture a glimpse of this grand old revolutionary, cheered to the sound of a military band that had been provided for the occasion.

Kropotkin, who had been impressed by the American people's sense of individual liberty, thought that the short-term interests of the many and various nations of the Russian empire would best be served by forming a loosely structured, federal, democratic republican assembly, similar to that of the Confederation of Independent States (C.I.S.), which did, in actual fact, develop in the aftermath of the Marxist coup in 1990. His excuse for supporting a "revolutionary" government or assembly, an idea he had rejected all his life, was the need for unity in order to win the war against Germany. Kropotkin did not go so far as accepting a post in Kerensky's Provisional Government although he was personally offered one by Kerensky himself. He did, however, establish a warm relationship with Kerensky's predecessor, Prince Lvov, whose devolutionist policy of strengthening and extending the autonomy of local and regional administration clearly appealed to Kropotkin. In

[67]Wilde, O., *De Profundis*, London: Methuen, 1950, page 112.

late August Kropotkin attended the National-State Conference in Moscow. This conference, which had no legislative authority, was convened by Kerensky, who was pro-war, in order to gain broad-based support for his Provisional Government. Kropotkin, assuming the role of a practical military man, after discussing the military tactics of the allies goes on to declare:

> "It seems to me that it would be proper for us here at this assembly of the Russian land to state our firm desire that Russia be openly declared a republic. And, citizens, the republic must be a federated one, in the sense in which we see it in the United States, where every state has its own legislative bodies, these legislative bodies deciding all the interior problems while the Republic in all its decisions needs the consent of several states or of all the states...It seems to me that if this assembly were to approve our desire that Russia be declared a republic, we would have thus facilitated the work of the Constituent Assembly, and all the peoples of Europe and America would be thankful to us. Comrades, let us promise each other that we will not stand divided into right and left. We have but one fatherland, and for the whole of it we must be ready to die, the conservative and radical."[68]

The above extract seems at first sight remarkable. It was, however, essentially a practical position. He saw no use of talking about a future anarchist utopia whilst German guns were threatening the very survival of the Russian nation. Also, and perhaps much more importantly, he was fearful of a monarchist restoration or a Marxist-communist dictatorship, both of which were a real possibility. Beyond this, he saw little point in alienating France and America who were of course in favour of Russia becoming a federal democratic republic similar to that of their own. Had Russia developed along this path it might well have avoided 70 years of ruthless dictatorship and become an equal member of Europe whilst allowing the provinces

[68]Sack, A.J., *The Birth of the Russian Democracy,* New York, 1918, pages 466-68.

of the empire to develop along their own path through constitutional autonomy from the center. This, however, is an optimistic assessment. The American federal system, however much promise it might have shown in the late 19th century, developed after World War II into a repressive global empire.

Underlying Kropotkin's practical standpoint there were deep theoretical convictions. Russia, he believed, was following a similar pattern to that of the French Revolution. Russia was not yet ready for an anarchist revolution as the February uprising had merely resulted in the abolition of the monarchy and brought Russia into line with the historic developments of 18th century France. Russia would first have first to reach the republican stage before it could continue on the social revolutionary path toward anarchy. This is similar in some respects to the Marxist idea of a dictatorship of the proletariat preceding the emergence of a stateless society. Marxism, however, was the construction of one person's mind. Republicanism, however much its values have been drowned in blood, did at least at some time in the past, represent the popular aspirations of the people in revolt.

According to Kropotkin republicanism (and nationalism) is not, in its pure form, incompatible with social anarchism. The inclusion of legislative assemblies within Kropotkin's republican vision, despite its concessions to decentralisation, federalism and local self-administration, was in essence a non-anarchist standpoint. Previously he had always been equally hostile to the state in all its forms: republican, socialist and monarchic. His 1917 position, however practical, could only have served to alienate him further from the Russian anarchist movement. Since 1914 Kropotkin had drifted both emotionally and intellectually from the majority of his comrades within the anarchist movement. In 1914 he had disagreed upon the tactical value of the anti-militarist standpoint and by 1917 had shown himself willing to advocate a revolutionary government. In the eyes of his comrades Kropotkin had unfortunately committed the Marxist error of contaminating the end (the flowering of social anarchy) to the means-end of governmental and administrative rule.

The seizure of power by the state-communist or Bolshevik party in October of the same year had profound results for all Russian people. One result of the Bolshevik coup was that after three years of estrangement, Kropotkin recovered his former faith and was inevitably drawn back towards his old comrades. The anarchists, long before the October coup, had predicted that state-socialism, if it should ever come into being, would be one of the most useless, destructive and hideously totalitarian systems of all time. Although the anarchist critique of the state-communist ideal has now been proved historically correct again and again, this was not the case in 1917. At this time, large sections of the populace were willing to at least entertain the idea of the state-socialist experiment as a method of solving the serious economic and social chaos of the immediate post-revolutionary period. The anarchists were, however, horrified. Kropotkin in particular, who despite his latent republicanism, had never ceased being opposed bitterly to any form of state-socialist dictatorship. His pronouncements upon the subject of the Bolshevik dictatorship from this period until his death in early 1921 are reminiscent, in virtue of their clarity and vigour, of some of his earliest political writings upon the subject of "revolutionary dictature". The fall of the Provisional Government effectively ended Russia's involvement in the war and, apart from a few anarchists who joined the ranks of the Communist Party, it soon became apparent that the Bolsheviks had come to represent the single most important threat to revolution and the liberation of the Russian peoples.

During the spring and summer of 1918 Kropotkin became involved with a grouping known as the Federalist League. This league was a small discussion group composed of people who were in one way or another opposed to the centralised economic, political and cultural life of Russia by the Bolsheviks. In a speech entitled *Federation as a Means to Unity*. Kropotkin stressed the need for Russia to give up its imperialist hold over the multifarious nations of the Tsarist era and encourage the development of regional autonomy and local self-government:

> “The idea grows stronger nowadays as to the necessity for the Russian people to give up definitely its inclination towards hegemony over the peoples that surround them. The impossibility of directing from one single centre 180 million people spread over an exceedingly chequered territory, considerably larger than Europe, becomes everyday clearer. As it becomes daily clearer that the true creative power of these millions of men could only exert itself when they will feel they possess the fullest liberty to work out their own peculiarities and build their life in accordance with their aspirations, the physical aptitudes of their territories and their historical past.”[69]

If we closely examine the events in the former Russian empire since 1990, it is precisely these aspirations which have come to the forefront.

On April 12, 1918, the Bolsheviks surrounded the Anarchist Club in Moscow with artillery and fired on those anarchists who attempted to resist arrest. The following day the few remaining anarchist presses were forcibly closed down and during the next couple of months anarchists became subject to intense persecution. The mild and scholarly Federalist League was suppressed and the Kropotkins were thrown out of their apartment. They decided to accept internal exile in a small village

[69]"Federation as a Means to Unity", speech delivered on January 7 1918, to the Federalist League. "Federatsiia-Kak put'k ob'edineniiu", *Golos Minuvshago,* 1, 1923. Tr. and quoted at length in "Peter Kropotkin on Man and Society", *Centennial Expressions on Peter Kropotkin,* S. Alexander, L.A., Calif., Rocker Pubs. Com., 1942.

called Dimitrov about forty miles north of Moscow. The final years of Kropotkin's life were comparatively lonely and isolated. Although he was personally left unmolested, the simple possession of one of his works would often "lead to immediate arrest".[70]

On his arrival in Dimitrov Kropotkin took the opportunity to try to finish his *Ethics*—a task which he had put aside for 15 years and which he was never able to complete. The first volume (of a projected two-volume work) was pieced together posthumously using two long articles which he had published in the *Nineteenth Century and After* magazine in 1904 and 1905, followed by his unfinished manuscript for the first volume. The second volume was to have contained his own ethical teachings. The beginning sections of the *Ethics* are biologically and anthropologically based. They provide a valuable extension of many of the themes explored in *Mutual Aid*. The later chapters are rich in ideas and his analysis of Spencer's and Guyau's ideas at the end of the book give a fairly clear idea of his opinion of late 19th century ethical teachings. Kropotkin in his later works was very concerned with the development of neo-vitalist perspectives in both ethics and evolutionary theory. Guyau is generally acknowledged as attempting to account for the concept or perception of vitalism in positivistic terms. Kropotkin suggests that Spencer only included ideas upon animal sociality and the development of human morality in 1890 after the editor of the *Nineteenth Century* had discussed Kropotkin's ideas upon mutual aid with him.

Although Kropotkin was now a very old and frail old man, he almost certainly would have completed his *Ethics* had he not been hampered by the harsh conditions under which he was forced to live in his final years. The winters were

[70] Alexander Berkman, *The Russian Tragedy,* London: Phoenix Press, 1986, page 46.

severe, fuel was extremely scarce and the whole family was frequently forced to live in one room. Kerosene for lighting became unobtainable and finding enough food to eat became a problem. The Kropotkins, though, considered themselves more fortunate than many, as they had a cow and Sofia was able to obtain sufficient produce from their vegetable garden. They were occasionally given gifts from anarchist comrades, especially the Ukrainian anarchist Makhno whom Kropotkin had briefly met before leaving for Dimitrov. Kropotkin, became closely involved with village life, founding a museum and taking an active part in the Dimitrov Co-operative Union. It was eventually suppressed by the Communist Party. Taking an active part in a peasant co-operative was a fitting end for a man whose writings, of whatever shade, had always stressed the need to support village and community life.

In the spring of 1919 a meeting was arranged between Kropotkin and Lenin. The meeting was not a happy one. Kropotkin talked of the significance and importance of the co-operative movement which Lenin spitefully dismissed as "Children's play things" with no relevance to the "goals of socialism".[71] Kropotkin wrote several damning letters to Lenin, two of which have survived,[72] and to which he never replied. These letters so infuriated Lenin that he felt cause to remark to another Bolshevik: "I am sick of this old fogey. He doesn't understand a thing about politics and intrudes with his advice, most of which is very stupid".[73]

Around this time Kropotkin wrote a detailed assessment of the situation in Russia addressed to the *Workers of Western Europe*. This was published widely in

[71]"Conversation with Lenin", Spring 1919, recorded by V.D. Bonch-Bruevich in "Moi vospominaniia o Petre Alekseeviche Kropotkine", *Zvezda*, 4, 1930. Tr. by M.A. Miller in *Selected Writings on Anarchism and Revolution*, Cambridge, Mass., M.I.T. Press, 1976, pages 325-32.

[72]"Two Letters to Lenin", March 4, 1920, and December 21, 1910. Published by V.D. Bronch-Bruevich, "Moi vospominaniia o Petre Alekseeviche Kropotkine", *Zvezda*, 6, 1930. Tr. by M.A. Miller, in *Selected Writings*, op.cit., pages 335-9.

[73]Shub, David, "Kropotkin and Lenin", *The Russian Review*, XII, 4, Oct. 1953, page 233.

the Western press and was Kropotkin's most outspoken public criticism of the Bolshevik dictatorship:

> “As to our present economic and political situation, the Russian revolutions, being a continuation of the great revolutions of England and France, are trying to reach the point where the French revolution stopped before it succeeded in creating what they called "equality in fact", that is, economic equality. Unhappily, this effort has been made in Russia under a strongly centralised party dictatorship. This effort was made in the same way as the extremely centralised and Jacobin endeavour of Baboef. I owe it to you to say frankly that, according to my view, this effort to build a communist republic on the basis of strongly centralised state communism under the iron law of party dictatorship is bound to end in failure. We are learning in Russia how *not* to introduce communism, even with a people tired of the old regime and opposing no active resistance to the experiments of the new ruler. The methods of overthrowing an already enfeebled government are well known to ancient and modern history. But when it is necessary to create forms of life, especially new forms of production and exchange, without having examples to imitate; when everything must be constructed anew; when a government which undertakes to furnish every citizen with a lamp and even the match to light it, and then cannot do it even with a limitless number of officials,–that government becomes a nuisance. It develops a bureaucracy so formidable that the French bureaucracy, which requires the help of forty officials to sell a tree broken down by a storm on the national highway, is a mere bagatelle in comparison. The immense constructive work demanded by social revolution cannot be accomplished by a central government, even if it had to guide it something more substantial than a few socialist and anarchist handbooks. It has the need of knowledge, of brains and of the voluntary collaboration of a host of local and specialised forces which alone can attack the diversity of economic problems in their local aspects. To reject this collaboration and to turn everything over to the genius of party dictators is to destroy the

> independent centres of our life, the trade unions and the local co-operative organisations, by changing them into bureaucratic organs of the party, as is the case at this time. That is the way *not* to accomplish the revolution, to make its realisation impossible. And that is why I consider it my duty to put you on your guard against borrowing any such methods."[74]

Shortly before his death the famous anarchist duo Alexander Berkman and Emma Goldman visited the Kropotkins in Dimitrov. Goldman relates how Kropotkin, with "boyish exuberance", proudly showed her around Sofia's vegetable garden which had been so productive that even after exchanging surplus for cattle fodder they were still able to share produce with poorer villagers.[75] Despite the beautiful summer weather their conversation inevitably turned to current events and Kropotkin told his guests that through destroying the co-operative movement "the great link between the country and the city" had been uselessly severed and was the primary reason for Russia's economic breakdown.[76] Their "mad passion for centralisation, inefficiency, corruption and ignorance of agrarian questions" were, he concluded, mere trifles in comparison to the brutality of the methods:

> "What I want to particularly point out to you at this time," as Kropotkin looked at me with his eyes full of pain, and indignation and his voice trembling, "is the attitude of the Bolshevik state to the people, to both the individual and the collectivity. I can hardly speak of it quietly. Suppression and terrorism, these are Bolshevik means, applied even to the friends of the revolution. Instead of deepening the revolution, they are now concerned only in securing governmental power. They have entirely lost sight of the very essentials of the revolution: continuous, progressive revolutionising of the masses; the largest opportunity for

[74]"Letter to the Workers of the West", April 28, 1919. Published in various radical papers in 1920. In *Revolutionary Pamphlets: A Collection of Writings by Peter Kropotkin,* edited with an introduction, biographical sketch and notes by Roger N. Baldwin, New York, Dover Publications, 1970, pages 254-6.

[75]Goldman, Emma, *Living My Life,* New York, Dover Publications, 1971, Vol 2, pages 863-4.

[76]Goldman, Emma, *My Disillusionment in Russia,* New York, Doubleday, 1923, pages 153-9.

> the encouragement of the people's initiative, self-expression, and voluntary self-organisation, lost sight of. Lost sight of it, did I say? No, they are deliberately and systematically suppressing, even exterminating every symptom of it. That is the terrible tragedy of the Russian Revolution."[77]

Kropotkin's outrage was undoubtedly justified as thousands of anarchists languished in jail and the Bolsheviks systematically dismantled the last remnants of Russian anarchism by the most brutal methods. Soon after Goldman and Berkman left Kropotkin, the local village co-operative was liquidated by the Bolsheviks. They arrested the leaders and other key workers of the Union. In his last years Kropotkin placed considerable hope in the co-operative movement. It was perhaps this event which prompted the writing of *What to do?*—an uncharacteristically pessimistic and despairing document on the subject of revolution.

With the onset of winter Kropotkin's health declined rapidly. He died in the early hours of February 8, 1921. The whole village came to pay their respects. As the coffin was carried to the train bound for Moscow the children strewed the way with pine branches. The funeral took place on the 13th February in Moscow. A mile long funeral procession consisting of 100,000 people slowly traversed the five-mile journey from the Palace of Labour to the cemetery of the Novo-Devichii Monastery where he was laid to rest. The funeral was both a protest and a tribute. The authorities could not have been seen to suppress opposition with so many foreign journalists present at the event. The fiery black and scarlet banners of the assembled anarchist groups proclaimed, "Where there is authority there is no freedom". The defiant speeches delivered at Kropotkin's graveside represented the last organised

[77]Alexander Berkman *Reminiscences of Kropotkin*, Freedom, London, March 1922, page 15.

mass demonstration by anarchists in Russia until the onset of Gorbachev's Perestroika nearly 70 years later.

Chapter 2

Kropotkin and the Birth of Ecology

Climate Change, Systems Theory and Non-equilibrium Ecology

A paradigm shift in ecology occurred in the 1960's. Ideas of natural harmony were replaced by models of change and disharmony. A contemporary ecologist uses Earth's many periods of glaciation to pose questions "about the stability of nature". He claims that, "continental glaciation is a comparatively recent discovery" that, was "not influential in the study of natural history until the twentieth century". Moreover, "it was commonly believed among ecologists before the 1960's that…the middle and high latitudes, the tropics had been characterised by climatic constancy."[78] Botkin concludes, "now we know that there was climate change in all latitudes, and that throughout the tenure of our species on this planet climate has varied."[79] Kropotkin's work upon dynamical geology and palaeo-ecology, specifically embraced fluidity and change in nature. Botkin's belief that, there was no conception of environmental non-equilibrium until the 1960's is false. It is indicative of an inadequate knowledge held by historians of ecological science about Kropotkin and Reclus.

Kropotkin was a pioneer of the scientific study of climate change in the quaternary and tertiary periods. Von Toll wrote in 1898 that:

> "Kropotkin was till lately alone in maintaining that parts of Asia, and especially middle Siberia, were also glaciated during the quaternary period."[80] Kropotkin claimed that, "in 1874 F. Schmidt and myself were the only two Russian geologists who ventured the hypothesis that the

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[78] Botkin. Daniel B., *Discordant Harmonies: A New Ecology for the Twenty-First Century*, Oxford University Press 1990, pages 57 and 62.

[79] Botkin. ibid, page 58

[80] Von Toll, *Proposal for an Epedition to Sannikoff Land*, The Geographical Journal, Vol.12 1898 page 166.

> boulder clay of Russia has been deposited by an ice sheet…now its extension, almost as far as Kiev, is a fact fully established."[81]

In Kropotkin's opinion scientific evidence was "pointing in the direction of a simultaneous glaciation of both hemispheres—though not necessarily to the same extent—and to simultaneous development of glaciers in the mountain regions of the equatorial regions." Kropotkin concludes that, "we must accustom ourselves to the idea that climate, like everything else on the earth, is a changeable element". [82] In a number of articles Kropotkin discusses the palaeo-ecology of Europe and Asia in the post-glacial period; as the predominant terrestrial ecosystems changed from lakes to prairie and forest land over thousands of years. Kropotkin wrote articles upon the discovery of tertiary flora in the Arctic[83] and geological work in South America[84]. The fact that the Pampas had once been covered in ice and the Arctic in temperate forests revealed that, the Earth had been more uniformly warm or cold at different periods. Kropotkin hoped Antarctic explorations would uncover similar discoveries.[85]

Kropotkin favoured the theories of James Geikie, who correctly thought that, "changes in the eccentricity of the earth's orbit which are known to exist, coupled with certain changes in the direction and force of the oceanic currents" were responsible for the changes in climate.[86] Kropotkin also gave some weight to the idea that solar variations might be partly responsible, for "we know from Lord Kelvin and Helmholtz that the sun's radiation is a variable quantity".[87]

[81] Kropotkin, *Recent Science*, *The Nineteenth Century Magazine*, Jan.1894 page 150, footnote 21

[82] Kropotkin, *Recent Science*, *The Nineteenth Century Magazine*, Jan.1894 page 156,

[83] Kropotkin, *Baron Toll on New Siberia And The Circupolar Teritary Flora*, The Geographical Journal Vol 16 1900 pages 95-8

[84] *The Pampas*, The Geographical Journal, 1894 pages 318-21

[85] Kropotkin, *Recent Science*, *The Nineteenth Century Magazine*, July 1895.

[86] Kropotkin, *Recent Science*, Jan.1894 page 155

[87] Kropotkin, *Recent Science*, Jan.1894 page 157

Kropotkin was attracted to "dynamical geology". The advance of glaciation science had been impeded by Tyndall's polemic against James Forbes, who, hypothesised that ice-sheets are "plastic enough to overflow continents". Upon the basis of glacial photography and the work of physicists, such as Tresca and Helmholtz, Kropotkin concludes that, "under certain pressure all solids flow like liquids…and, the great objections to the glacial theory, based upon the supposed non-plasticity of ice, has been entirely removed.[88]

Before working on glaciation Kropotkin achieved international fame by figuring out the structure of the Siberian or East Asian mountain ranges. In an article upon the formation of mountains he makes a detailed examination of contemporary physical experiments upon plastic materials. B. Willis' laboratory work, Kropotkin believed, validated E. Suess' and A. Heim's hypothesis that, mountains were created through "lateral force—a force working sideways, and not from beneath" Photographs revealed "all possible forms of folds and bends" but, most importantly, "the so-called over-thrusts and under-thrusts. The shovelling of immense masses of older strata above younger strata, which for a long time offered such difficulties in explaining the structure of the highlands of Scotland."[89]

Kropotkin's consideration of mountain formation and the plasticity of ice-sheets developed into a broad interest with the physics of dynamical processes. Concerning the alloys, Kropotkin concludes that, "the great puzzle of plasticity in the most solid rocks and the most brittle metals thus ceases to be a puzzle"[90]. Chemistry, Kropotkin predicts, will not advance until the chemist "applies the principles of

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[88] Kropotkin, *Recent Science*, Jan.1894 page 152
[89] Kropotkin, *Recent Science*, *The Nineteenth Century Magazine*, Nov. 1897 page 808.
[90] Kropotkin, *Recent Science*, *The Nineteenth Century Magazine*, Feb. 1897 page 257

dynamics, upon which all other physical sciences are built."[91] In an article upon the spectral analysis of stars, whilst discussing the formation of new stars from nebulous clouds, he concludes that, nebulae are "living" at a very "much more rapid speed" than had been previously conceived. "In the movements of these remote agglomerations we learn to feel the continuous life of Nature, its continuous change, its evolution."[92]

Instability for Kropotkin was the hallmark of a living system. Like the universe, processes upon Earth cannot be characterised in terms of static and unchangeable order:

> "...the idea of stability which was hitherto attached to everything which man saw in nature, is broken down, destroyed and put to naught! Everything changes in nature, everything is incessantly modified: systems, wages, planets, climates, varieties of plants and animals, the human species—Why should human institutions perpetuate themselves!
>
> Nothing remains, everything modifies itself, from the rock which appears to us immovable and the continent which we call "terra firma", to the inhabitants, their manners, their customs, their ideas.
>
> What we see around us is only a passing phenomenon which ought to modify itself, because immobility would be death. These are the conceptions to which modern science accustoms us.
>
> But this conception dates almost from yesterday. Arago is almost our contemporary. And yet when he spoke one day of continents which sometimes arose out of the seas and were sometimes submerged by the waves, a learned friend made this remark "But your continents spring up then like mushrooms", so much was the idea of immobility, of stability in nature, rooted in the mind as this epoch, to-day continual change, evolution, is one of the most popular terms."[93]

Kropotkin's conception of nature as ever-changing and highly dynamic is a very modern theme. Opposing ideas of constancy and stability dominated scientific

[91] Kropotkin, *Recent Science*, *The Nineteenth Century Magazine*, Aug. 1893page 252
[92] Kropotkin, *Recent Science*, Nineteenth Century, vol. 31, 1892, page 444.
[93] Kropotkin, *Revolutionary Studies*, Section III, The Commonweal, London, 2 January 1892, page 2.

thinking in a diversity of fields, including ecology, genetics and biogeochemistry, until the end of the 1960's.

It used be thought that the biosphere was extremely stable, but we now know that climatic conditions cannot be taken for granted at the present rate of atmospheric pollution.

Molecular scientists of the late 1970's were surprised, by the fluidity and dynamism of genomic processes:

> "The application of new molecular techniques reveals that, beneath the level of the chromosome, the genome is a continuously changing population of sequences. Mobility, amplification, deletion, inversion, exchange and conversion of sequences create this unexpected fluidity on both an evolutionary and developmental time scale."[94]

In ecology, landscapes were once conceived as reaching climax states that, without some unforeseen catastrophe, would remain unchanged. Indeed, fires were repressed in forests requiring them. Management practices based upon ideas of permanent mature natural states resulted in an accumulation of combustible material and catastrophic fires of much greater intensity and extent. Lessons learnt from such events combined with the development of non-equilibrium perspectives has led to the practice of controlled burning in some fire-adapted forests. Conservationist's stress the need to anticipate change or replicate the effects of natural disturbance processes in management practices.[95]

The geographers Humboldt (1769-1859), Suess (1831-1914) and Reclus (1830-1905) were the first thinkers to adopt a "global ecological view of the

[94] Dover, G. A. and Flavell, R. B., (eds.) *Genome Evolution*, Academic Press, London, 1982, blurb on back cover.

[95] For a general overview of disturbance dynamics see Pickett S. and White P., *The Ecology of Natural Disturbance and Patch Dynamics*, Academic Press 1985.

Earth"[96]. Kropotkin and Reclus undertook a considerable amount of geographical and political work together and were both admirers of Humboldt. Reclus, although acknowledged as a pioneer of global ecology and systems theory, is more often overlooked in favour of Marsh.[97] Reclus and Marsh were contemporaries, who corresponded with one another and were "appreciative of each other's work, but differed in their essential approaches".[98] The scholarly focus upon Marsh, rather than Kropotkin and Reclus, has led to a distorted picture of the development of ecological ideas. Botkin uses Marsh as paradigmatic of ecological thought from 1860-1960. Marsh, a pioneer of the conservationist paradigm, saw nature in static terms, as "constant and immutable".[99] Nature was an unchanging harmonic balance. Human activity for Marsh "is everywhere a disturbing agent. Wherever man plants his foot, the harmonies of nature are turned to discords."[100] Botkin criticises Marsh's pessimism and hopes that in the future our "great civilisation" may play a "positive role in the environment."[101] Reclus also criticised Marsh's pessimism.[102] Kropotkin and Reclus were optimists and anarchist revolutionaries who believed dramatic change in society and nature is normal and necessary.

Hagen claims that, "by about 1900 the major themes of ecological discourse were established: change and uniformity, instability and equilibrium, competition

[96] Jacques Grinevald, *Sketch for a History of the Idea of the Biosphere*, in *Gaia in Action*, Peter Bunyard (ed) UK, Floris Books, 1996, pages 36-7. See also my *Anarchism and Ecology: The Historic Relationship,* in Purchase G. *Anarchism and Ecology,* Montreal, Black Rose Books, 1997, pages 33-74

[97] Marsh, George Perkins, *Man and Nature* (1864), Cambridge Mass. Havard University Press, 1967. Reclus reviewed Marsh's book, see Reclus E, *Man and Nature*, (Ed. Purchase G.), Sydney, Jura Media, 1995.

[98] Dunbar G., *Elisee Reclus: Historian of Nature,* Conneticut, 1978, page 45. Marsh was very impressed with Reclus' *The Earth*, and wrote an introduction for the English Translation. Marsh's introduction was not however published until 1960 in the Geographical Journal.

[99] Marsh, George Perkins, *Man and Nature*, pages 29-30.

[100] Marsh, George Perkins, *Man and Nature*, page 36.

[101] Botkin, D., *Discordant Harmonies*, page 13.

[102] Dunbar G., *Elisee Reclus: Historian of Nature*, page 44.

and co-operation, integration and individuality."[103] Although true, Kropotkin was the first bring these themes together in ways similar to how they are understood by contemporary non-equilibrium ecologists. What makes Kropotkin noteworthy in comparison to his scientific contemporaries is the *denial* of equilibrium and constancy in nature and a rejection of organismal analogies.

Early ecological scientists generally characterised environments and human societies in organismal terms. Kropotkin did not employ organismal analogies in his descriptions of nature or society and it is not surprising that one of his chief intellectual rivals was Spencer. "Spencer thought that the biological community, what we would now call and ecosystem, was a kind of organism"[104] Both Cowles and Clements portrayed ecological succession as the equivalent of the developmental process of an individual organism. Cowles believed ecosystems "began as an embryo, passed through a series of developmental stages, attained maturity and eventually died"[105] For Clements, "succession was not just analogous to ontogeny; it was ontogeny".[106] The idea that a biological or human community is an organism is rejected by most ecological scientists and sociologists today. Debate concerning the Gaia hypothesis has kept the organism vs. system alive but it seems clear to me that the biosphere is more usefully characterised as a super-system rather than a super-organism.

Kropotkin never conceived nature and society in holistic terms in which individual and individualistic processes are irrelevant. But, Kropotkin thought the hypothesis that, social and natural systems could be explained purely in terms of

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[103] Hagen, J., *An Entangled Bank: The Origins of Ecosystem Ecology*, New Jersey, Rutgers, 1992, page 11.
[104] Hagen, J., *An Entangled Bank*, page 3.
[105] Hagen, J., *An Entangled Bank*, page 18.
[106] Ibid, page 82.

individual competition, as Darwin, Huxley, Spencer, Forbes, Lloyd Morgan, Romanes had done, was scientifically and philosophically insupportable. S. Forbes, in his 1887 study of lakes, was the first person to develop the idea of the 'biological community', but he too was a follower of Spencer, and "like Darwin and Spencer, believed that ceaseless strife was also a mechanism for insuring social harmony and progress".[107]

Tansley [108] coined the term ecosystem in 1935, but the full implications of the concept were not appreciated until several years afterwards. Odum considers that, the mathematician Lotka "independently came up with the idea of the ecological system and should share the credit with Tansley"[109]. Modern systems approaches reject the organismic thesis and have "freed the ecosystem concept from a rigid geographical basis"[110]. Systems may be "arbitrary", with respect to the "phenomena under consideration" as well as to their "spatial" location or extent. There exist systems level processes that can be studied in mathematical, theoretical or scientific terms without reference to their constituents or, even as a "tangible physical entity".[111]

Similarly, Kropotkin's and Reclus' social anarchism was not premised upon the geographically located community. They emphasised the potential role of non-territorial communities of interest in the development of decentralised and non-hierarchical social systems, which they argued, most truly reflected the dynamic processes of nature. Kropotkin hoped for a world where government and state had been replaced by the self-organisation of humanity; working, communicating and

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[107] Hagen, J., *An Entangled Bank*, page 9.

[108] Tansley, A, G. *The use and abuse of vegetational concepts and terms*, Ecology 16, 1935, pages 284-307.

[109] Odum, E., *Ecology and Our Endangered Life-Support System*, Mass, Sinauer, 1993, page 72.

[110] Hagen, J., *An Entangled Bank*, page 87.

[111] Naaiman, R, and Decamps H., *The Ecology and Management of Aquatic-Terrestrial Ecotones*, New Jersey, 1990, page 23.

organising, both locally and globally in every conceivable area of mutual interest, enquiry, expertise, need or endeavour, in a non-centralised and co-operative way.

> "If we closely scan the development of the human mind in our times we are struck by the number of associations which spring up to meet the varied requirements of the individual of our age . . . already now, Europe is covered by thousands of voluntary associations for study and teaching, for industry, commerce, science, art, literature, exploitation, resistance to exploitation, amusement, serious work, gratification and self denial, for all that makes up the life of an active thinking being . . ."[112]
>
> "Communes will continue to exist; but these communes are not agglomerations of men in a territory, and know neither walls nor boundaries; the commune is a clustering of like-minded persons, not a closed integer. The various groups in one commune will feel themselves drawn to similar groups in other communes; they will unite themselves with these as firmly as with their fellow-citizens; and thus there will come about communities of interest whose members are scattered over a thousand cities and villages."[113]

Kropotkin's vision foreshadowed social-technological developments involving decentralised systems for the production and communication of information, such as the web, the existence of which in cyberspace is not straightforwardly 'a tangible physical entity'.

Geography

Kropotkin played a major historic role in bringing together geographical data upon vast and remote areas of Asia and disseminating it in both popular and scientific works. In addition to providing the material for two volumes of Reclus' (19 vol.) *Universal Geography*, Kropotkin continually kept abreast of Asian exploration in order to meet his obligations to successive editions of a number of major reference works, contributing for example, scores of articles covering around 1 fifth of the terrestrial world for three editions of the *Encyclopaedia Britannica*. Kropotkin also

[112] Kropotkin, *The Place of Anarchism in Socialistic Evolution* (pamphlet), London, W.H. Reeves, 1887

[113] Kropotkin, *Paroles d'un Révolté*, Paris, Flammarion, 1885, quoted in Eltzbacher, *Anarchism*, London, A.C. Fifield, 1908, pp.156-8.

continually contributed many articles and maps to the *Journal of the Royal Geographical Society* upon recent explorations and discoveries relevant to Asian geography and glacial theory. The longest of these articles (also published as a book in French by Reclus) provided a general survey of the *Orography of Asia* (1904) and contains interesting biogeographical hypotheses concerning the distribution of botanical boundaries in relation to the geology of Asia.

From the middle of the 19th century, geographers, began to "examine land settlement and use from the aspect of resources, where wilderness was seen as being threatened or endangered".[114] Kropotkin complains in *Mutual Aid*, how it had become nearly impossible to study the social behaviour of regional or meta-populations of large mammals. The invention of gunpowder had resulted in "civilization" taking a 300 year hunting trip, leading to the decimation of "animal societies or nations".[115] Kropotkin in his Encyclopaedic work also focused upon the natural and economic resources of the Russian Empire, Central and Eastern Asia, noting many instances of over-exploitation.

Ethology

Ecology was used interchangeably with "ethology at the beginning of 20th century". At this time, ethology, "the idea that animal behaviour could be understood by close observation in the wild, was a radical idea".[116]

The study of animal behaviour and its role in evolution was highly developed in Russia prior to the publication of Darwin's *Origins*. Kropotkin was part of a tradition inspired by the pioneering work of K.F. Kessler and K.F. Rul'e. Kropotkin drew upon the later work of some brilliant 19th century Russian scientists, most

[114] Bramwell, A., *Ecology in the 20th Century: A History*, page 15.
[115] Kropotkin, *Mutual Aid*, 1915 popular edition, page 37.
[116] Bramwell, A., *Ecology in the 20th Century: A History*, New Haven, Yale University Press 1989, page 41.

relevantly Severtsov, Menzbir, Brandt and Poliakov.[117] Poliakov and Kropotkin explored Siberia together as members of the same scientific team. Severtsov, like Kropotkin, was a man of action who achieved considerable international scientific fame. Kropotkin befriended Severtsov, describing him as a “great zoologist, a gifted geographer and one of the most intelligent men I ever came across”.[118] Severtsov was a pioneering ecologist whose interests overlap with those of Kropotkin, most relevantly, the “analysis of Migration” and “close attention to the fluid relations among organisms” in Severtsov’s zoogeographical studies of the distribution, causes and evolutionary consequences of phenotypic/behavioural plasticity and diversity.[119]

Kropotkin believed that laboratory approaches were of little use in the study of animal behaviour and thought that field experience was sadly lacking among biological researchers. He admired the animal psychologist C. Lloyd Morgan (1852-1936). Morgan thought that experimental work upon animals should be conducted under conditions closely corresponding to their natural habitat. In later editions of *Animal Behaviour*, Morgan, after having read Kropotkin “conceded the prevalence of mutual aid in nature.”[120] Spencer, after considering Kropotkin’s ideas wrote some articles concerning “morality in nature” that were subsequently included in later editions of his *Ethics* and Vol. X of his *Synthetic Philosophy*.[121] However, Morgan, Romanes and Spencer, despite modifying their views in response to Kropotkin’s ideas never thought that mutual aid was a significant factor in evolution.

[117] All these thinkers to varying extents included co-operation as an element of animal behaviour and factor of evolution and are analysed in Todes, *Darwin Without Malthus*, Chapters 6,7 & 8, pages 105-165

[118] Kropotkin, quoted in Daniel P. Todes, *Darwin Without Malthus: The Struggle for Existence in Russian Evolutionary Thought*: New York, Oxford University Press 1989, page 147

[119] Todes, *Darwin Without Malthus* page 149

[120] Morgan quoted in Todes, *Darwin Without Malthus* page 136

[121] [121]Kropotkin, *Ethics, Origin and Development*, Tudor Publishing Co.,1947, footnotes on page 35 and 287

Kropotkin was particularly interested in the adaptive plasticity of animal behaviour. Social animals adaptively modify behaviour and transmit through imitation or instruction this knowledge to other members of their social group. Animals that are able to communicate and learn from information provided by others, Kropotkin thought, would be much better able to survive in changing or newly colonised environments. Generally, what higher animals lack in genetic and morphological inflexibility, they compensate for through instinctual flexibility. The ability to adopt and evolve novel behaviour is especially prevalent among highly social species.[122]

The social transmission of information between organisms, both within and between generations, is an important and often overlooked factor in evolution. Influential ecological thinkers have followed Kropotkin in this respect. Elton, who laid the "intellectual foundation for the study of energy flow in ecosystems, developed niche theory and the idea of the food chain"[123], in later works emphasised the "inheritance of social traditions—a mechanism he thought might rival natural selection." Like Kropotkin, Haeckel and Lloyd Morgan, Elton believed that, even "lowly creatures possessed considerable freedom to make choices"[124]

Kropotkin when considering the senses of lower organisms discusses experiments upon amoeba and larger marine invertebrates. Such organisms, he concludes, are discerning about their environment and diet. Unpleasant and pleasant meals were 'remembered' by the organism. After reviewing a number of experiments upon the responses of marine invertebrates to warmth, light, narcotics, electricity

[122] See discussion of alteration of habits and social cooperation in *Evolution and Environment*, page 142.

[123] Elton C., *Animal Ecology and Evolution*, London: Sidgwick and Jackson, 1927, and Oxford University Press, 1930.

[124] Hagen, J., *An Entangled Bank*, pages 52-61.

etc., Kropotkin concludes that, even at this level, organisms exhibit “discriminative powers” involving “choice”, “memory”, “free-will” and “some rudiments of reasoning.” The brain and the nervous system developed as an “unbroken continuum” from the sense and behavioural capacities of bacteria.[125]

Upon the basis of experiments, similar to those discussed by Kropotkin, a contemporary biologist concludes that, quick, flexible “behavioural” response to environmental challenges by bacteria reveals that, “the brain, the whole neuromuscular system, and therefore the capacity for culture are foreshadowed in the most rudimentary organisms”.[126]

The ability to learn and communicate is not restricted to animals with a complex nervous system: “bees in particular have excellent memories and an impressive ability to learn. We also know that a bee has very few neurones compared to even the smallest an most primitive vertebrate.”[127] Experiments comparing the learning ability of ants and rats in mazes of the same plan reveal that the ant’s “ultimate performance is almost as good as that of the rats.”[128] The differences in learning and communicative ability, between vertebrates and invertebrates, is “primarily quantitative”.[129] But, observation of animals with progressively more complex nervous systems show that, behaviour becomes increasingly more flexible and the ability to instruct more pronounced. The advantages of flexible behavioural responses, has led to a “progressive shift of information transfer by the genome to

[125] Kropotkin, Senses of Lower Organisms, *Recent Science*, *Nineteenth Century*, Aug. 1896. Kropotkin cites Heackel’s *Essay on the Origin and Development of Sense–Organs* (1897), Romanes, *Mental Evolution in Animals*, J. Lublock, C.Lloyd Morgan, Max Verworn, Hertwig and Binet, as having undertaken pioneering work in this area.

[126] Bonner, J. T., *The Evolution of Culture in Animals*, Princeton University Press, New Jersey, 1980, page 56.

[127] Bonner, J., Ibid, page 200.

[128] Bonner, J., Ibid, page 204.

[129] Bonner, J., Ibid, page 205.

transfer by the brain"[130] The non-genetic or "behavioural transmission of information" allows for great plasticity and is an "incredibly clever way of getting around the upper limit to genetic complexity."[131]

> "Another important feature of plasticity in behaviour is the capability of making inventions. We think of much of human historical progress as one invention succeeding another...but lesser animals are also capable of behavioural inventions than can be passed on, and there are some well-known examples: for instance, the tit in central Britain that learned how to peck open the milk bottles and take the cream at the top. This invention soon spread from one small area and now full milk bottles are not safe anywhere in the British Isles. As one might expect, primates are even better at inventing, and there have been many well-documented cases of a useful invention that the spreads in a population."[132]

Inheritance is most commonly explained in genetic terms, but in mammals and birds the direct social transmission of behavioural adaptations is equally important.

Kropotkin's also explored links between animal's social behaviour and morality. Haeckel, who first coined the term ecology, believed that human sympathy, altruism and morality were the result of "ethical instincts derived from our animal ancestors".[133] Darwin entertained similar views in his *Descent of Man*.[134] Kropotkin, like Haeckel and Darwin, believed that morality grew out of social instincts among animals and developed in his *Ethics* the interesting thesis that, our ancestors gained moral lessons from observing the social life of other animals.

More generally, many people still think of wild animals as "beastly". A widespread belief to the contrary is relatively recent. *Mutual Aid* has served an historic role in changing attitudes towards animals and stimulating study of the relationship of pre-human sociality and the origins of our moral sensibilities.

[130] Bonner, J., Ibid, page 115.
[131] Bonner, J., Ibid, page 218.
[132] Bonner, J., Ibid, page 217.
[133] Bramwell, A., *Ecology in the 20th Century: A History*, page 41.
[134] Part 1, Chapter III

Huxley's *The Struggle for existence in Human Society*[135], prompted Kropotkin to write *Mutual Aid*. Huxley portrayed animal life in terms of individualistic conflict: a "gladiator's show...whereby the strongest, the swiftest and the cunningest live to fight another day"[136]. Human relations prior to civilization had been "a continual free fight, and beyond the limited and temporary relations of the family, the Hobbesian war of each against all was the normal state of existence"[137].

Kropotkin is the most important historical figure in the articulation of co-operative models of animal life, natural systems and evolutionary processes. *Mutual Aid* was an immediate popular success and has stimulated many evolutionary thinkers to appreciate or re-examine the co-operative dimension of animal life and evolution.

Co-operative models of evolutionary processes remain controversial. Studies have shown that contemporary ecological textbooks devote vastly more space to competition and predation in comparison to mutualism. This is despite the fact that there is no evidence that competition is more important than co-operation in the formation and maintenance of bio-systems. [138]

Leading contemporary ecologists and evolutionary scientists, e.g. E. Odum and S. J. Gould, regard Kropotkin highly. Gould states that, "Kropotkin created a dichotomy within the general notion of struggle—two forms with opposite import (1) organism against organism of the same species for limited resources leading to competition; and (2) organism against environment, leading to co-operation."[139] Gould concludes that, "the central logic of Kropotkin's argument is simple,

[135] Huxley, T. H., *Nineteenth Century* 23 (February 1888) pages 161-80, reprinted in *Essays: Ethical and Political*, London: Macmillan 1903.
[136] Huxley, T. H., Ibid, pages 6-7.
[137] Huxley, T. H., Ibid, page 8.
[138] Odum, E., *Ecological Vignettes*, Harwood, 1988, page 174.
[139] Gould, S. J., *Bully for Brontosaurus*, Hutchinson Radius, 1991, page 335

straightforward, and largely cogent". Odum states that: "Kropotkin suggested that there were two kinds of natural selection, namely organism vs. organism, which leads to competition and organism vs. environment which leads to mutualism. To survive an organism does not compete with its environment as it might with another organism, but must adapt to or modify its environment and its community in a co-operative manner"[140]

A recent environmental history book claims that, the idea of co-operation was initiated and "understood by Darwin and Kropotkin", and that, the next most significant personality in the field was Allee (1885-1955), "who headed at The University of Chicago a noted group of ecologists who spent much of the 1930's documenting the existence of co-operative communities in nature."[141] Allee, working a generation after Kropotkin's death, regarded Kropotkin's influence in quite general terms: "Kropotkin's remarkable if uncritical book… served the admirable purpose of keeping this [mutual aid] idea alive and popularising it."[142]

A study of Kropotkin and Allee claims that, Allee "was stimulated to re-examine Kropotkin's thesis when, by chance, he discovered that even such lowly animals as isopods aggregate most eagerly to form social clusters. From this, he was led to review abundant evidence of swarm formation in the living world. Starting with the single-celled photosynthetic organism *Euglena*."[143]

Allee was also a group-selectionist. Although group selection was first invented by Darwin to explain human moral conscience, Kropotkin is historically the most influential advocate. The individual vs. group selection debate that occurred in

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[140]Odum, E., *Ecology and Our Endangered Life-Support System*, Mass, Sinauer, 1993, page 209.

[141] Nash, F. R., *The Rights of Nature: A History of Environmental Ethics*, Sydney, Primavera Press and The Wilderness Society, 1990 page 59

[142] Allee, W. *The Social Life of Animals*, London, The Book Club, 1949, page 12

[143] Ho, *Natural Being and Coherent Society* in *Gaia in Action*, Peter Bunyard (ed) UK, Floris Books, 1996 page 293

biology and ecology during the 1960’s began with the Huxley-Kropotkin exchange in the 1890’s.

Group selection is one of several levels or types of selection as categorised by present day evolutionists, but became something of an evolutionary heresy in both biology and ecology from the 1960’s onwards. However, influential ecologists, such as E. Odum were much more reluctant to abandon it than evolutionary biologists. Wynne Edwards, a respected, though unorthodox contemporary theoretical and field biologist/naturalist, is the most well known contemporary advocate of group-selection. Gould stated that, the “consensus” may “perhaps be incorrect”[144] with respect to a total rejection of group selection as conceived by Wynne-Edwards. Gould did not think that group selection represented a serious threat to Darwinism, only the narrow or ultra Darwinism with which he consistently took issue. In his most considered defence of group selection Wynne-Edwards explores the ideas of Allee and Sewall Wright in some detail.[145] Allee worked at the same University of Chicago laboratories as Sewall Wright. Wright’s work on structured populations has attracted considerable contemporary interest. Wynne-Edwards, regards Allee as a pioneer of, several fields of study, including “interspecific mutualism”.[146] Darwin and Kropotkin also discussed such phenomena as mixed flocks.

Kropotkin discusses at length mass aggregations and migrations, but his primary focus is upon groups rather than the species. Kropotkin believed that, many animals and birds live, at least for significant parts of the year, in structured communities and societies involving complex patterns of inter-personal interaction

[144] Gould., S. J., *Caring Groups And Selfish Genes*, in his book *The Panda’s Thumb*, Harmondsworth, Penguin Books, 1983, page 75.
[145] V. C. Wynne-Edwards, *Evolution Through Group Selection*, Oxford Blackwell Scientific Pubs., 1986, pages 202-208, 275-80.
[146] Wynne Edwards ibid, page 39

among animals that ‘know’ and ‘recognise’ one another. Some animal species do not associate, e.g. snowy owls and tigers, but these are the exception rather than the rule. In *Mutual Aid* Kropotkin observes an “overwhelming numerical predominance of social species over those few carnivores which do not associate.”[147] Most animal populations are not composed of individuals unknown to one another. They engage in various forms of social behaviour, both competitive and co-operative, within coherent groups and populations. Kropotkin’s examples include the “numerous packs of Black Bear of Kamtchatka” and the “compound families of elephants”.[148] Allee came to very similar conclusions:

> “The growing weight of evidence indicates that animals are rarely solitary; that they are almost necessarily members of loosely integrated racial and inter-racial communities, in part woven together by environmental factors, and in part by mutual attraction between the individual members of different communities, no one of which can be affected without changing all the rest, at least to some slight extent.”[149]

Both Allee and Kropotkin describe numerous examples of how economic co-operation enhance the survival of the individual, group and the species. Economic co-operation is used here in a broad way to describe great variety of activities concerned with daily survival and not directly concerned with reproduction, e.g. collective mechanisms for defence against predators (mobbing in birds), co-operative hunting behaviours (lions), group moderation of the environment (beavers), migration, hibernation (combined heat or numbers), defence of feeding territories from competitors, etc. Kropotkin argues that economic co-operation results in differential reproductive success among social species in comparison to solitary ones.

[147] Kropotkin, *Mutual Aid*, page 36.
[148] Kropotkin, *Mutual Aid*, pages 39 and 44 footnote. 1
[149] Ho, *Natural Being and Coherent Society* in *Gaia in Action*, Peter Bunyard (ed) UK, Floris Books, 1996 page 293

Ecology has traditionally focused upon the "economic behaviour of organisms in groups" whilst "evolutionary theory has focused almost completely on the genealogical products".[150] Kropotkin, a geographer and an ecologist was particularly concerned to show how co-operative economic behaviour altered or improved the environment and survival chances of individuals, groups or species. Kropotkin thought that, co-operation "favours the development of such habits and characters as insure the maintenance and further development of the species, together with the greatest amount of welfare and enjoyment of life for the individual, with the least waste of energy."[151]

An adequate appreciation of economic efficiencies that can result from group or co-operative behaviour, Eldredge asserts, is what is missing from "reductive gene's-eye" type theories of evolution. Eldredge argues that under the standard neo-Darwinian synthesis as elaborated by Fisher, Wright, Dobshansky etc., "organisms have come to be regarded, at base, as being concerned exclusively with the maximization of reproductive success." Whereas Darwin had thought that, "offspring tend to inherit those features that confer relative economic success". The neo-Darwinists argue "*all* aspects of living systems are to be understood, ultimately, as an outgrowth of competition for reproductive success". They suggest "that organisms actively seek to maximise their reproductive success" whereas Darwin "saw natural selection as a simple accumulator". The neo-Darwinists:

> "see economic competition as a direct reflection of real competition for reproductive success…Natural selection is transformed from a passive accumulator to a dynamic process… responsible at bottom, for the organization of all manner of biotic entities: species, local ecosystems, and most of all, social systems. This reformulation of natural selection into active mode…in

[150] Eldredge N. and Grene M, *Interactions: The Biological Context of Social Systems*, page 77.
[151] Kropotkin, *Mutual Aid*, 1915 popular edition, page 14.

sociobiological literature maybe a downright perversion of the genuine evolutionary principle of natural selection"[152]

The main criticism of Kropotkin's ethology is that, he conceives animal groups as egalitarian communities. Kropotkin in a political article even claims that, Darwin's work showed how, "animal societies are best organised in the communist-anarchist manner".[153] Severtsov, whom Kropotkin often misinterpreted, was particularly interested in differences between individuals of the same group or species, for example, age hierarchies among social eagles during feeding.[154] The role of hierarchies and territories in the social allocation and conservation of resources is also central to Allee's and Wynne Edward's approach. Although territories and hierarchies are competitive, they are *socially* generated. Unlike Huxley's individualistic conceptions they are manifestations of social competition and structure.

Speciation, Behvioural/Developmental Plasticity and Environment.

Introductions to ecology usually contain a chapter on speciation.[155] Kropotkin was interested in the effects of behavioural/developmental plasticity and novelty upon the evolution of species and ecosystems.

Kropotkin believed that migration and subsequent geographical isolation was the most common speciation process (allopatric speciation), but he also thought that changes in diet or behaviour could result in sympaticric speciation (speciation without prior geographical isolation). In both cases Kropotkin stressed the active role that organisms play in their own evolution. The idea that a chosen new behaviour pattern can initiate speciation through being favoured by natural selection was

[152] Eldredge N. and Grene M, *Interactions: The Biological Context of Social Systems*, page 5.
[153] Todes, *Darwin Without Malthus* pages 130-1
[154]Todes, *Darwin Without Malthus* page 149
[155] For example, Odum, E., *Ecology and Our Endangered Life-Support System* 209-18, Barnes, R., and Hughes, R., *Introduction to Marine Ecology*, 2nd Ed., Oxford, Blackwell, 264-83.

advocated by Baldwin, whose leading advocate in Britain was Lloyd Morgan. Kropotkin admired Morgan's works and held a similar position to him but without the emphasis upon natural selection. Bowler, in his authoritative study of the period regards Kropotkin as an innovative and independent proponent of the importance of behavioural change in speciation. Bowler observes that, both Morgan and Kropotkin saw "life as a purposeful activity."[156]

Like Wallace and Romanes, Kropotkin was similarly impressed by Gulick's work upon the 200 species of snails limited to separate valleys of a single Island. Kropotkin had personally examined the snails in Boston "under the guidance of Hyatt".[157] Kropotkin believed the weight of evidence indicated that, the primary mechanism of speciation was geographical isolation or allopatry. A viewpoint initially rejected by Darwin, but which, has until fairly recently been the prevailing orthodoxy among evolutionary scientists. Kropotkin examines the role that local topographical peculiarities might have played in allopatric speciation in Canada (which he had visited and undertaken geological studies) and depressions of the central Asian plateau (Caspian, Aral, Baikal) upon the evolution of different species of fish, seals and plants.[158]

Although populations can become passively separated by geological events Kropotkin believed that migration/colonisation was an active or positive behaviour pattern in animals. He uses the example of the horse, deer etc, to illustrate how migration and colonisation facilitated speciation through initiating geographical and reproductive isolation:

[156] Bowler, P.J., *The Eclipse of Darwinism*, Baltimore and London, J. Hopkins University Press, 1983, pages 81-2

[157] Kropotkin, *Recent Science*, (Experimental Morpholgy) Sept 1901, page 436.

[158] Kropotkin, *Evolution and Environment*, Quebec, Black Rose Books, 1995, page 132.

> "The part played by migrations in the appearance of new species has been rendered quite obvious. We know perfectly well that the ancestors of our horse migrated over both Americas, Asia, Europe, Africa, and probably back to Asia, and that each step in those migrations was marked by the apparition of some new characters. The same remark applies to the mastodons and their descendants, the elephants; to the common ancestors of the camel and the llama, and to the Ungulata. It may be taken now as a general rule that the evolution of new species chiefly took place when the old ones were compelled to migrate to new abodes, and to stay there for a time in new conditions of climate and general surroundings" [159]

Kropotkin focused upon processes such as mass migration, local extinction, isolation and re-colonisation because they are distinctive processes of life in Siberia and a major preoccupation of the Russian naturalists with whom he worked or was influenced. Migration also countered arguments characterising nature in terms of over-population and competition. Overcrowding, food shortages and climatic stress rather than resulting in fighting, frostbite and starvation, could be overcome by searching for suitable habitat elsewhere. Migration, Kropotkin believed, explained the "absence of intermediate forms" in the fossil record.[160] 'Habitat tracking', is of great contemporary interest in palaeontology and conservation ecology. For example, in response to the future effects of climate change upon geographically 'fixed' wildlife reserve systems it is suggested that parks may have to be moved up or down mountains or the coast in order to allow for the movement of species.

Modern palaeontology and palaeo-ecology reveals that habitat tracking is a significant factor in both speciation and stasis. Contrary to Kropotkin's beliefs, tracking may be a source of stasis because the movement of species from one locale to another in response to local environmental change results in neither extinction nor adaption. Eldredge argues that, this may explain why species "tend to persist with

[159] Kropotkin, *Recent Science* (Fragmentary nature of fossil record), August 1892, page 231.
[160] Kropotkin, *Evolution and Environment*, Quebec, Black Rose Books, 1995, page 130.

little appreciable change throughout their existence"[161] as exhibited by the appearance and disappearance of "related but different varieties"[162] and an overall pattern of "weak and typically vacillating anatomical changes."[163] Vrba and Eldredge argue that, major speciation events are linked to more widespread, universal or global environmental change involving severe "habitat disruption" during which tracking leads to "disjunct populations, the very precondition needed for true species fragmentation". This leads to increasing speciation at a time of increasing extinction, such that, new species "have a far better chance of becoming established in a newly under-populated world."[164] Habitat tracking and isolation during periods of rapid environmental stress/change may play a pivotal role in speciation but, during more predictable times similar behaviour patterns may result in prolonged periods of non-change.

Kropotkin believed that animals suffering environmental stress also avoided competition or death by feeding on "different sorts of food" or adopting "different modes of life."[165] Such activities could result in sympatric speciation by causing spatial or temporal asynchronosities within populations sharing the same geographical region:

> "Some frogs, accustomed to wet ground, have been forced to migrate to a dry ground, and we learn from Hutton that not only a new variety was originated in this way, but that it differed from the parent stock by laying its eggs somewhat earlier, so that cross-breeding became impossible."
> "...a butterfly, if it does not find enough of the plant upon which it is accustomed to deposit its eggs, deposits them on some other nearly related plant, and, as has

[161] Eldredge, *Reinventing Darwin*, page 67.
[162] Eldredge, *Reinventing Darwin*, page 74.
[163] Eldredge, *Reinventing Darwin*, page 77.
[164] Eldredge, *Reinventing Darwin*,, page 150-1.
[165] Kropotkin, *Evolution and Environment*, Quebec, Black Rose Books, 1995, page 133.

been shown by Standfuss, a new variety of that butterfly comes into existence."[166]

Changes in host plants, habitat or reproductive season, Kropotkin argues, can result in temporal (allochronic speciation) or seasonal/climatic (phenological) isolation. It is further suggested that changes in diet or temperature triggered morphological and behavioural changes in insects and small animals. A number of recent studies suggest that the host, prey or habitat specificity of many insects and small invertebrates, especially when mating or oviposition occurs upon or near the food source/host/prey, may lead to assortive mating and reproductive isolation.

Many insects have lifecycles synchronised closely with their host or prey. The eggs of herbivorous insects may be activated to hatch by responding to the resumption of the fluid flow of the host plant in the spring.[167] Adult parasitoids (insects which lay eggs close to hosts eggs or on the host larvae) "can become conditioned to the odour emitted by the faeces of their hosts without coming into direct contact with the host."[168] "The chemistry of the larval host can alter the structure or mixture of sex pheromones produced by adults".[169] The isolating effects of diverging life-cycles are greatly increased if the mating period is relatively brief and the various hosts are asynchronous.[170] It is also necessary to consider the "indirect effects" of changes in "host association—i.e., escape from parasitoids, predators pathogens, and/or competitors."[171] Exploitation of new resources or habitats may create new niches, expand species/ecosystem richness or diversity and reduce competition by utilising resources more efficiently.

[166] Kropotkin, *Evolution and Environment*, page 133.
[167] Tauber C. and Tauber M., *Sympatric Speciation in Insects: Perception and Perspective* in Otte D. and Endler J., (eds.) *Speciation and its consequences*, Sinauer, Mass. 1989, page 319.
[168] Tauber C. and Tauber M., *Sympatric Speciation*, page 325.
[169] Tauber C. and Tauber M., *Sympatric Speciation*, page 322.
[170] Tauber C. and Tauber M., *Sympatric Speciation*, page 319.
[171] Tauber C. and Tauber M., *Sympatric Speciation*, page 323.

Field evidence in support of sympatric speciation has come from the accidental introduction of foreign insects[172] into new environments, or the deliberate introduction of foreign agricultural crops.[173] Experimental evidence is provided by laboratory results involving observation of successive generations of flies housed in mazes and conditioned to particular habitats. The flies can choose where they live and reproduce. The experiment "resulted in nearly complete reproductive isolation due to a gradual breakdown in migration of sub-populations utilising two spatially and temporally separated habitats."[174]

Many larger vertebrates have flexible instincts, requiring practice or refinement. Animals learn to apply genetically inherited behaviour patterns in particular environments, through trial and error (a term invented by Morgan), imitation or instruction by the parents or social group. Many bird species directly inherit only a rough template of their call leading to regional dialects in some instances. If calls are part of sexual mating recognition patterns it can be reasonably argued that, learned behavioural phenotypes may initiate sympatric speciation: "Behavioural plasticity has produced regional dialects, and these serve an isolation function which might lead ultimately to morphological differences and separate species."[175]

Kropotkin also considers adaptive polyphenic plasticity of animals and plants in relation to speciation. The ability to exploit another sympatric niche or survive in fluctuating environments by having two or more distinct phenotypes/developmental pathways, confers considerable evolutionary advantages. Kropotkin argues that

[172] Tauber C. and Tauber M., *Sympatric Speciation*, page 325.
[173] Michael White, *Modes of Speciation*, San Francisco, W.H. Freeman, 1978, page 233.
[174] Rice W. and Salt G., *The Evolution of Reproductive Isolation as a Correlated Character Under Sympatric Conditions: Experimental Evidence*, Evolution 44 (1990) page 1148.
[175] Bonner, J., Ibid, page 214.

animals and plants are able to respond to “constantly changing surroundings”[176] and experiment with different niches or climatic regions through utilising “several developmental lines”[177].

Kropotkin, like Clements, was particuarly interested in alpinism. He notes how a lowland species grown in alpine conditions appear to quickly adapt and closely resemble alpine morphology. Bowler in his assessment of Kropotkin’s defence of the inheritance of acquired characters states that, he “exposed the weakness” of his own arguments when he “conceded that alpine species when “grown at a lower altitudes soon loose their particular characteristics”.[178] Bowler is partially mistaken. Kropotkin, additionally thought that, the evolution of phenotypic/developmental plasticity was an important evolutionary development in its own right. “Unlike Darwin and his followers who had ignored what was to be Johannsen’s crucial distinction between phenotype and genotype”[179], Kroptotkin was familiar with Johannsen’s most important work reading it shortly after it was published around 1909.[180]Kropotkin, however, did not accept upon the basis of experimental work, that phenotypic variation in plants could not be inherited. Kropotkin claims Johannsen also held the view that, “without inherited variations ‘Selection would have no hereditary influence’”.[181]

Success in varying environments does not require genetic change, only genetic regulation of expression in response to environmental cues. Phenotypic variation in plants is not however superficial. It can effect “ecological,

[176] Kropotkin, *Evolution and Environment*, Quebec, Black Rose Books, 1995, page 237.
[177] Kropotkin, *Evolution and Environment*, page 231.
[178] Bowler, P., *The Eclipse of Darwin*, page 87
[179] Bowler, P., *The Eclipse of Darwin*, page 25
[180] Kropotkin, *Evolution and Environment*, Quebec, Black Rose Books, 1995, page 218-9
[181] Johannsen, *The Genotype Conception of Heredity*, American Naturalist 1911, quoted by Kropotkin in *The Direct Action Of Environment and Evolution*, The Nineteenth Century, Jan 1919 pages 86-87

morphological, anatomical, karyological, physiological, biochemical, and molecular characters” resulting in a situation where it is often difficult to make any strict separation between genotype and phenotype.[182]

Kropotkin thought that the “enormous plasticity” of plants was a “protective adaption”[183]. Selection had eliminated species without “enough plasticity”[184] because they were unable to meet environmental challenges with a sufficiently broad phenotypic repertoire. Modern experimental research suggests that natural selection has acted on plants strongly in favour of “general purpose genotypes which adjust by phenotypic plasticity to different environmental conditions”[185], as well as favouring or “allowing the evolution of highly specific patterns of plasticity”[186]. The evolution of what are now characterised as genetically regulated or programmed developmental responses, Kropotkin thought, appeared to have substantial experimental grounding.[187]

Kropotkin was of the view that migration or environmental change might favour one developmental pathway over another and result in speciation. The idea that stimulus dependent phenotypes may be sorted by natural selection was first raised by J. Baldwin in 1896 and developed by C. H. Waddington early in the 20th century.[188] There is a revival of interest in Waddington’s idea of “genetic assimilation and the mechanism of ‘phenocopy’, whereby a phenotypical adaptation

[182] Schmid, B., *Phenotypic Variation in Plants*, Evolutionary Trends in Plants, Vol. 6 (1) 1992, page 48.

[183] Kropotkin, *Evolution and Environment*, page 158.

[184] Kropotkin, *Evolution and Environment*, page 156.

[185] Schmid, B., *Phenotypic Variation*, page 51.

[186] Schmid, B., *Phenotypic Variation*, page 53.

[187] See Kropotkin’s discussion in *The Direct Action Of Environment and Evolution*, 1919 pages 86-87

[188] Ho W., *Environment Heredity and development*, in *Beyond Neo Darwinism* (ed. Ho) John Wiley 1988 page 272-3

is replaced by a variation in the genotype."[189] West-Eberhard has recently suggested that environmental change, in one part of a species' range or geographical isolation, may result in the loss of particular environmental cues leading to the fixation of one and the loss of another developmental pathway, later: "rapid genetic changes might occur because the genome is released from the constraint of having to produce two well-canalized phenotypes".[190]

More generally, changes in diet or environment, often create considerable stress for an organism. Animals and plants do not directly adapt to changing environmental conditions, as Kropotkin and many other ecologists of his period believed. Genomes, it is now thought, remain relatively stable most of the time, but during times of environmental stress rapid novel genomic restructuring can occur. It is hypothesised that natural selection of particular or entirely novel environmentally induced phenotypes may sometimes result in speciation:

> "The 'reaction range' of the individual—the range of its possible responses to environmental challenges—can be defined only a posteriori, because the environmental conditions may have unique aspects. A population exposed to a new environmental challenge will show a range of novel responses, and the variability is the material on which selection can operate...When the environment changes drastically and induces new phenotypes, evolution through genetic assimilation is possible. The store of previously 'neutral' variation becomes visible to natural selection and new combinations of genes can become fixed. For example, variations in the number of repeated sequences can assume selective importance in the new environment if they affect the ease with which the phenotype is induced. Even without changes in DNA composition, induced heritable epigenetic variations provide a way out of stasis, especially in groups without a segregated germs line. They provide an additional source of variation on which natural selection can act."[191]

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[189] Sinha, C., *Biosocial Evolution*, in Ho (ed.) *Beyond Neo Darwinism*, page 353

[190] West-Eberhard quoted in Jablonka E and Lamb M. *Epigenetic Inheritance and Evolution*, Oxford, Oxford University Press, 1995, page 240.

[191] Jablonka E and Lamb M. *Epigenetic Inheritance*, pages 281-4 passim.

Although animals and plants do not as a rule directly adapt, environmental stress induces epigenetic change, variation and novelty. There is an increasing body of experimental evidence pointing to the fact that even in mammals these topological variations of genetic expression may be heritable due to incomplete erasure. A retrotransposon inserted upstream of the agouti gene in mice silenced an epiallele resulting in a wide variety of physiological and pathological effects. This epigenetic modification was inherited because of "incomplete erasure in the female germ line". "Because retortransposons are abundant in mammalian genomes, this type of inheritance may be common." Disruption of gene expression by transposable elements is generally thought to be a "major source of sporadic disease", hence there is no suggestion of environmental adaption. However, such mechanisms are a "major source" of heritable "phenotypic variation" that may undergo further evolution by subjection to the processes of natural selection.[192]

Epigenetic changes (transposition, amplification, methylation etc) are facilitated by the chromatin marking system that also has a role in defence and repair processes and developmental timing. In recent years it has been plausibly speculated that epigenetic change caused by environmental stress may sometimes cause heterochronic changes; that is, alterations in developmental timing. The idea that novel heterochronic changes can very occasionally produce a successful new species is currently a very popular one. Many evolutionary biologists consider it to be one of the major causes of large mutations responsible for speciation in animals with complex developmental processes and early germ line segregation. Changes in timing can affect many things all at once. Hence, it has been persuasively argued, as

[192] Morgan D., Sutherland H., Marin D., Whitelaw E., *Epigenetic inheritance at the agouti locus in the mouse*, Nature Genetics, Vol. 23, #3 November 1999, pages 314-318 and 254-6

Goldschmidt did in the 1930s, that, it is very much more likely to "produce a fairly co-ordinated novel organism"[193].

Symbiosis and Symbiogenesis

Symbiosis was coined by Anton de Bary, in 1878, but, there were many other pioneers in the field. Symbiogenesis was first hypothesised in the late 19th century and coined by Merezhkovskii in 1909. It describes the symbiotic origin of species and ecosystems. Mutualism and symbiosis are often confused with each other. Generally it may be said that mutualism[194] refers to co-operative behaviour between individuals of the same species whilst symbiosis refers to an intimate and long lasting, though not necessarily mutually beneficial[195], physical relationships between individuals of different species.

Mutual Aid is about mutualism not symbiosis. Although Kropotkin didn't contribute directly to the symbiosis debate, Sapp in an authoritative history of symbiosis correctly claims that, *Mutual Aid* has been of enormous significance in keeping the idea of co-operative evolution a compelling issue for successive generations.[196]. Kropotkin maintained professional relationships and friendships with scientists who were conducting or supporting symbiosis research, including, Patrick

[193] Jablonka E and Lamb M. *Epigenetic Inheritance*, page 222.

[194] Interspecific Mutalism is a term used to describe co-operation between different species without the intimacy of symbiosis. Mutualism began as a political movement in France and the most important representative of the tradition is the early anarchist thinker P. J. Proudhon. See D.H. Boucher, *The Idea of Mutualism, Past and Future* in Boucher (ed.) *The Biology of Mutualism. Ecology and Evolution*, London: Croom Helm, 1983 pages 1-28. Boucher also discusses the influence of Kropotkin upon the development of mutualism as a biological concept in some detail.

Although symbiosis is responsible for the evolution of more complex unicellular organisms the evolution of multi-cellular organisms most probably resulted from mutualism. The debate as to whether multicellular organisms resulted from competition or co-operation between unicellular organisms remains a live debate. See relevant works by L. Buss and Bonner.

[195] Many symbiotic relationships most probably began as parasitic or pathogenic invasions, which were later modified. Some symbiotic relationships, for example, mycorrhizal associations between plant roots and fungi can be beneficial or harmful to their hosts depending upon environmental conditions. See Angela Douglas, *Symbiotic Interactions*, New York, Oxford University Press, 1994, pages 2-7.

[196] Sapp, J., *Evolution by Association*, Oxford Uni Press, 1994 pages 20-3.

Geddes, Marie Goldsmith and Yves Delage. Goldsmith and Delage thought very highly of Kropotkin and included a summary of his mutual aid theories in their *Theories of Evolution*.[197]

When discussing the evolution and physiology of the cell Kropotkin argues that, the organelles are "independent" and "separate organisms", because, like the cell they "multiply only by subdivision".[198] He favoured Altman's 'co-operative colony' characterisation of the cell according to which the evolution and continuous functioning of the nucleus and cytoplasm are conceived as resulting from the economic co-operation of once free living microbes:

> "As to the cell, it is not, in Altmann's view, an elementary organism, but a *colony* of elementary organisms which group together according to certain rules of colonisation…These granules, he maintains, are identical with microbes; their shape, their chemical reactions, their movements, and their secretory functions are similar; but the granules of the protoplasm differ from bacteria in not being capable of a separate existence. They can only live in cells"[199]
>
> "At the present time, we know that no animal or plant, with the exception of the lowest unicellular beings, can be considered as one being—that each of them is a colony of multitude of micro-organisms"[200]

In an article upon the agricultural and ecological importance of symbiotic relationships Kropotkin discusses nitrogen fixing bacteria and mycorrhizal fungi. He also reports upon the discovery of sulphur and iron feeding bacteria in the Black Sea and speculates about their role within its ecosystems.

> "All these are evidently but separate instances of a much more general fact, which only recently became known under the general name of 'symbiosis' and appears to have an immense signification in nature. Higher plants depend upon lower fungi and bacteria for the supply of that important part of their tissues, nitrogen. Lower fungi associate with unicellular algae to form that great division of the vegetable world, the lichens. More than a hundred different species of

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[197] Goldsmith, M., and Yves Delage, *The Theories of Evolution* (1909) New York: B.W. Huebsch, 1912 pages 347-52

[198] Kropotkin, *Recent Science*, December 1892, page 111-4.

[199] Ibid, page 756-9.

[200] Kropotkin, *Recent Science*, August 1893, page 261.

algae are already known to live in the tissues of other plants, and even in the tissues and the cells of animals, and to render each other mutual services. And so on. Associations of high and low organisms are discovered every day; and when their conditions of life are more closely examined, the whole cycle of life changes its aspect and acquires a much deeper signification."[201]

"Symbiotic concepts of the cell and organism remained on the fringe of biological thought". Although "cytologists of the late 19th century recognised that it was possible that many cytoplasmic structures were self-reproducing from one cell generation to the next, many insisted that they were the products of nuclear activity."[202] Geddes also was of this view. The symbiogenesis theory of the evolution of the cell was unknown, ignored or denied by most leading researchers in the life sciences for much of the 20th century.

The development molecular genetics allowed for the application of nucleotide sequence analysis to cytoplasmic genomes and conclusively proved the symbiotic origins of nucleated cells. Eukaryotic or nucleated cells evolved in the later Pre-cambrian as a result of a series of mergers of prokaryotic or bacterial cells. This is well accepted in the case of two cytoplasmic organelles: plastids and mitochondria that evolved from cyanobacteria and proteobacteria respectively. These are the parts of the cell enabling plants to photosynthesise and animals to respire. Symbiotic associations with fungi allowed plants to colonise terrestrial habitats and symbiosis has been integral to the evolution and maintenance of some marine ecosystems (e.g. coral reefs) and virtually all terrestrial ones. Indeed, in recent years there has been a revolution in the understanding of the importance of symbiogenesis and symbiosis within the scientific establishment.[203] The neo-Darwinist, J. Maynard Smith, for

[201] Kropotkin, *Recent Science*, August 1893, page 266.

[202] Jan Sapp, *Evolution by Association* page 45.

[203] The most concise introduction to modern developments in symbiosis research is Angela Douglas, *Symbiotic Interactions*, New York, Oxford University Press, 1994. A history of Symbiosis research and theorising in addition to Jan Sapp's *Evolution by Association* is L.N. Khakhina, *Concepts*

example, recently stated that, he was “attracted by the speculative idea that chromosomes originated symbiotically”.[204]

Economics

Another major source of ecological thought is economics and energetics. Ecology and economics are derived from the Greek for house. The notion of a self-sufficient and well-organised household underlies both disciplines.

Industrial and capitalist approaches to agriculture had led to a belief that such methods were progressive or better upon the grounds of increased efficiency. Around 1850 researchers in Northern Europe began questioning the supposed inefficiency of peasant farming. They concluded that “in terms of energy units used, peasant productivity was greater that that of large capitalist farms”.[205] In *Fields, Factories and Workshops* Kropotkin gathered data from a wealth of similar studies together and presented them in a coherent way. Like *Mutual Aid* this study was a popular success and Kropotkin is quite well known as a pioneer of ecological-economic arguments favouring intensive, small-scale, organic, market garden approaches to food production based upon the grounds of energy efficiency.

Social, Urban and Agricultural Ecology

The rise of the green movement at the end of the 20th century was a novel historical development. Ecology is a new body of scientific description and knowledge upon which social, political and ethical ideas and practices can be premised. Ecological science suggests that political, social and economic

of Symbiogenesis: A Historical and Critical Study of the Research of Russian Botanists, New Haven, Yale University Press, 1992.

[204]Smith, J.M., *A Darwinian View of Symbiosis*, Margulis L and Fester, R., Symbiosis as a *Source of Evolutionary Innovation*, MIT Press, 1991, page 31.

[205] Bramwell, A., *Ecology in the 20th Century*, page 66.

arrangements must be compatible or enhance natural ecological processes. What harms such processes is ethically, politically and ecologically wrong.

There are ecological elements within the works of many ancient writers, but, it was not until the beginning of the last quarter of the 19th century that these ideas began to develop as a coherent environmentalist viewpoint. “Self-definition”; of consciously associating with this new political outlook “arose in the 1920s”. It did not “acquire a proper name until the early 1970s…when the scientific roots of ecologism merged into a political discipline, to become an ideology”.[206]

Kropotkin was the first person to mould proto-ecological concepts within economics, geography, geology and biology into a coherent political or social ecology. This is obscured because he defined his politics in terms of anarchism rather than environmentalism.

Kropotkin’s anarchism foreshadowed many movements associated with the history of modern political ecology, such as the green-city and the alternative, appropriate or intermediate technology movements.[207] Lewis Mumford, a major and highly respected urban theorist/historian was very much influenced by Kropotkin.[208] Odum, unconsciously follows Kropotkin when he argues for the need for moderately sized and self-sufficient cities in which “every inhabitant grows at least some of their vegetables in a greenhouse room”.[209] Odum also follows Kropotkin when he suggests that we should take a closer look at “traditional mutual aid combinations of

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[206] Bramwell, A., *Ecology in the 20th Century*, pages 13 and 15.

[207] Colin Ward in his annotated edition of *Fields, Factories and W’shops* (Freedom Press, London) makes out a convincing scholarly case for these claims.

[208] Horner, G.M., *Kropotkin and the City: The Socialist Ideal in Urbanism*, Antipode, Vol.10, pages 33-45

[209] Odum, E., *Ecological Vignettes*, Harwood, 1988, page 97.

agriculture and horticulture involving mixtures of annual, perennial, and tree crops, domestic animals, and fish ponds fed with manure and plant residues."[210]

The human need for a healthy social and urban environment dovetails with the need for a healthy natural environment. Kropotkin wrote three books upon prison issues and like most socialists viewed the impoverished urban environments of state-capitalist-industrial society as a major source of crime. Similarly, Odum questions the wisdom of spending money on prisons without adequately funding "economic services designed to see that the children of the poor do not become criminals."[211] What makes Kropotkin's thesis particularly relevant to present day thinking and an advance upon traditional socialist-environmentalist criminology is that, he thought an absence of meaningful and participatory community structure was an equally significant cause of criminal behaviour.

Kropotkin was the first person to contemplate the notion of the green city and envisioned self-sufficient cities based upon extended urban neighbourhoods utilising intensive horticulture for the production of food from organic wastes and the generation of energy from local or decentralised sources. The creation of clean, sustainable or self-sufficient cities is regarded as a desirable goal by many contemporary environmentalists.

Kropotkin advocated the "intensive" or market garden approach to vegetable and fruit production. He was particularly impressed by the techniques of the urban gardeners of Paris, Troyes and Rouen, and the peasant farmers of Jersey, Gurnsey and the Scilly Isles[212]. These gardeners had developed efficient and sophisticated systems for cultivating vegetables and fruit. The Paris gardeners, for example, on

[210] Odum, E., *Ecological Vignettes*, page 98.
[211] Odum, E., *Ecological Vignettes*, page 21.
[212] Kropotkin, *Conquest of B*read, Ch.XVII.

small plots within the limits of the city (they were attracted to Paris due to the prodigious quantities of stable manure), managed to export their produce to England. A carefully balanced organic feed was given to the crops on raised beds in frames or greenhouses and nurtured and forced by under soil heating (through steam pipes) and artificial light.[213]

Market gardening approaches and technological advancement Kropotkin hoped, might eventually allow urban centres to be able to grow most of their daily fruit and vegetable requirements. Vegetable and fruit production was to be integrated into urban life creating a more balanced urban-agrarian environment. Social and environmental stability was he believed, dependent upon an environmentally holistic approach. An approach, moreover, that not only stressed the need to integrate industrial and agricultural production and consumption within the human environment but also with nature's biological and evolutionary tendencies:

"The large town as well as the villages, must undertake to till the soil. We must return to what biology calls "the integration of functions" . . . the taking up of it as a whole—this is the course followed throughout nature."[214]

Kropotkin thought that scientifically informed approaches to organic composting combined with advances in glass house horticulture, might allow the city to feed itself through the intelligent recycling of its human, animal and vegetable wastes. Kropotkin thought that we had much to learn from the Chinese and Japanese who had developed composting techniques such that, they were able to maintain

[213] Kropotkin, *Conquest of B*read, Ch.XVII, and *Fields, Factories and Workshops,* (London, Hutchinson and Co., 1899) London, Thomas Nelson and Sons, 1912, pages 124-133; see also the lovely book Thomas Smith (F.R.H.S.), *French Gardening,* London, Utopia Press, 1909 (Kropotkin wrote the Foreword to this book).

[214] Kropotkin, *The Conquest of Bread,* op.cit., page 99.

dense populations through “utilising what we lose in sewage”.[215] There are many safe ways of treating sewerage and grey water non-chemically ranging from, the waterless toilet, ultra-violet light, sound, reed-beds and vermification. Although these are still very radical ideas to many people, even in the waste-industry, pilot studies of these techniques are very convincing and could most probably be developed within an urban context.

Kropotkin lamented the loss to the Russian revolutionary movement of so many enterprising and spirited people who, hoping to escape autocratic Russia had gone east to found colonies in Siberia. In a number of articles Kropotkin outlined numerous reasons why experimental communities inevitably fail.[216] Reclus was even stronger in his condemnation. He found isolated communal experimentalism "obnoxious", believing that, individuals wishing to construct "a wall between themselves and the rest of their race" could only be motivated by an egotistical and self-centred desire to live in isolation.[217]

Though he rejected experimental villages Kropotkin took a profound interest the possibilities for improving the productivity and quality of rural life. Peasant villages were to be transformed by appropriately scaled technology and improved agricultural techniques.

Kropotkin placed great faith in technological advancement in overcoming many of the problems of life that still unfortunately haunt us. Indeed, Kropotkin's reflections upon the future uses of resources like electricity deeply impressed many of his 19th century contemporaries. The advancement of technology would, he

[215] Kropotkin, *What Man Can Obtain From The Land*, Co-operative Wholesale Societies Annual for 1897, Manchester and Glasgow 1897, page 376.

[216] Kropotkin, *Small Scale Communal Experiments and Why They Fail*, edited by Purchase, G., Sydney, Jura Media, 1997

[217] *Anarchy*, Contemporary Review, London, May 1884, page 637.

rightly claimed, soon allow even the smallest village to be supplied with electricity and, thereby, benefit from the improved industrial and agricultural methods that science and technology had recently begun to develop. Electricity was first to be provided by appropriately scaled steam generators and, eventually, through the utilisation of local, renewable, or alternative energy sources, such as wind, micro-hydro or solar power.[218]

Although it will soon be the case that the majority of the worlds population will live in large cities, a little under a half, predominantly the most impoverished, still live in traditional villages. From a young age it was these people that Kropotkin most wanted to help. The introduction of sustainable agriculture, intensive organic horticulture and modern, and appropriately-scaled, industry and technology powered by local, renewable energy resources **is exactly what is still needed** in the impoverished and neglected villages of Africa, Asia and South America. Kropotkin's vision of co-operative and modern village life powered by clean local energy and fed by sustainable farming and local small industries, for compelling social and environmental reasons, remains as relevant today as it did a century ago.

Anticipating the contemporary interest in ecological or organic agriculture, Kropotkin rejected "[American] extensive" methods that in his opinion merely served to exploit the soil for short-term gain.

Instead of extensive, inefficient and environmentally damaging farming methods, Kropotkin, like many environmentalists today, advocated organic kitchen and market garden culture (horticulture) in and around village settlements along side traditional mixed field culture (agriculture). He thought that there was considerable

[218] *The Conquest of Bread*, 1913 edn., pages 100, 266, 294. Kropotkin also explored the recent developments in solar wind and water power in his *Recent Science* articles of August 1898, The Nineteenth Century, pages 271-280.

room for reform and inventiveness in agriculture, involving a more organic or integrated approach, that involved working with, rather than against nature.

He rejected individual ‘homestead’, or ‘estate’ farming, in favour of a co-operative and labour intensive approaches to agriculture that involved utilising micro-climates and natural features of the land “with all its varieties of slopes, aspects, watering, and so on, so as to have from it the largest amount of produce with the least waste of labour.”[219] Instead of turning a very large area over to wheat or stock, less fertile slopes should be given over to trees. In patches that received less frost, orchards and glass houses were to be included in order to gain the maximum advantages of local micro-climates. The maximisation of production he suggests is best achieved through “mixed” tree-plantings imitating “the natural grouping of trees of a forest”.[220] Forest gardens are created by placing a range of compatible economically valuable species together in a way that produces many useful products from a piece of land by mimicking the various micro-niches of natural forest ecosystems (canopy, lower canopy, shrub, ground cover etc.).

With traditional field crops Kropotkin thought that it was a good idea to use modern chemical fertilisers. But, it was only advisable to “supply fertilisers (chiefly nitrogen) at those periods of growth when most wanted.”[221] Rather than applying fertiliser at the time of sowing, as practised for most of the 20th century, farmers are, only now, learning to apply fertiliser later, when the plants are actually able to take it up, in an effort to stop pollution of rivers and ground water.

Kropotkin, was far more interested in organic systems that utilised mutualist or symbiotic relationships. He calls for the planting of clover underneath traditional

[219] Kropotkin, *What Man Can Obtain*, page 394
[220] Kropotkin, Experimental Farms, Nineteenth Century, November 1897, page 817
[221] Kropotkin, *What Man Can Obtain*, page 370.

grain crops in order to provide nitrogen naturally as well as improve the soil.[222] The use of green manure (used since Roman times) is currently undergoing something of a revival in an effort to reduce costs, as well as preventing pollution and soil erosion. Kropotkin also advocated preserving bio-diversity and experimenting with the use of native species through the establishment of native reserves and botanical gardens in newly colonised territories.[223]

At the present day degradation and environmental simplification are compelling farmers to take an ecological approach to their land. Prince Charles' organic hobby farm, or the Australian Landcare Movement are different instances of a new, and revolutionary, approach to agriculture. An approach that no longer considers the soil as "an inert mineral mass" but rather embraces the "only true conception—that the soil maintains life because it is living matter itself."[224].

Some modern readers of *Fields Factories and Workshops*, have been dismayed by the extent that Kropotkin was a technophile with regard to food production. Some of Kropotkin's suggestions, such as "intensive greenhouse potato production", have been justly "criticised on the grounds that more energy units would be required to increase production than would be produced for use."[225] However, *Fields, Factories and Workshops*, is often mistaken for something it isn't. The central and overriding purpose of the book was to prove Malthus wrong. Kropotkin argued that, through the intelligent use of the land in both urban and rural contexts, combined with innovative technologies and practices it was easily possible to feed an urbanised, industrialised and densely-populated country like the UK. Kropotkin's study was proven true during the second world war when the isolated

[222] Kropotkin, *Experimental Farms*, page 815.
[223] Kropotkin, *Experimental Farms*, page 816.
[224] Kropotkin, *Experimental Farms*, Nineteenth Century, page 820.
[225] Bramwell, A., *Ecology In The 20th Century*, page 87.

island nation successfully fed itself, at least in part, by reintroducing food production back into the city.

There is no doubt however, that Kropotkin, like some other notable ecological thinkers of the 19th and 20th century, such as Chayanov and Howard Odum, shared a degree of technophilia, which many people, including other ecologists, have found unwarranted. Chayanov envisioned "self-sufficient peasants flying into cities to attend a concert, and then returning home to milk the cows"[226] Whilst H. Odum envisioned taking over the management of urban ecosystems through large-scale environmental engineering. Although country people, at least in Australia, may occasionally fly to a city attraction and return the same day, this is hardly an energy efficient means of travel. Eugene Odum, disliked his brother Howard's "managerial ethos", complaining, "we cannot safely take over the management of everything".[227] Kropotkin's outlook, I suggest, fits somewhere in the middle of the spectrum between the sometimes grotesque technophilia of Chayanov and H. Odum and the technophobia of some segments of the contemporary green movement.

Kropotkin's social-ecological vision speaks to our time. In the 21st century we must learn to conserve nature, practice global co-operation and integrate ourselves with the ecological dynamics of Earth. In my opinion, and that of many others, this will not be achieved without rural development of the world poorest regions, improved agriculture practices and the development of sustainable urban ecosystems.

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[226]Bramwell, A., *Ecology In The 20th Century*, page 88.
[227] Hagen, J., *An Entangled Bank*, pages 139-40.

Chapter 3

The Mutual Aid Theories

Although Darwin did not use the term mutualism to describe social behaviour among animals he certainly considered that mutualistic behaviour had played an important part in the evolution of life. Darwin in his The Descent Of Man considers such phenomena as mixed “united flocks”, “warning calls”, “sentinels” and mutual grooming, hunting and defence.228 Darwin concludes: “it is certain that associated animals have a feeling of love for one another…”229, and:

> “however complex a manner this feeling may have originated, as it is one of high importance to all those animals which aid and defend each other, it will have been increased, through natural selection; for those communities, which included the greatest number of sympathetic members would flourish best and rear the greatest number of offspring”230

Kropotkin considered himself a Darwinian and reacted against the narrowing of Darwin’s theory by the social Darwinists. Kropotkin specifically directs us to the above quoted passages in which Darwin succinctly outlined the importance of the social instincts in evolution. Mutual Aid is an attempt to expand, explain and elaborate upon these passages, and others like them, that the social Darwinists had overlooked when they interpreted Darwin’s metaphor of struggle solely in terms of conflicting individuals.

The word mutualism was originally a social/economic/political term that had little to do with biological or evolutionary theory. Mutual societies developed in both

[228] Darwin, C., *The Descent of Man* (1871) Chap III. Princeton Uni Press edition, 1981, pages 74-5.

[229] Darwin, C., *The Descent of Man* (1871) Chap III. Princeton Uni Press edition, 1981, page 76

[230] Darwin, C., *The Descent of Man* (1871) Chap III. Princeton Uni Press edition, 1981, page 82

France and Britain in the wake of the French Revolution and the wide variety of doctrines developed in these groupings is collectively know as mutualism. Mutualism was the forerunner of both anarchism and socialism and its foremost exponent was Pierre-Joseph Proudhon who is widely and simultaneously regarded as one of the founders of anarchist theory and an important early socialist thinker.

Mutualism entered scientific discourse as a biological/zoological term in the early 1870’s through the works of the Belgian zoologist Pierre Van Beneden. His most famous book Animal Parasites and Messmates231 was published in many languages simultaneously during 1875-6 and was very influential. Van Beneden was certainly no socialist, though the term mutualism as a social, political and economic ideal, akin to socialism, was by this time so widespread that it is inconceivable that he was ignorant of its political content. Van Beneden was also a fervent follower of the Catholic faith. In consequence his observations upon mutualism among animals have many points of contact with the natural theology of the 17th and 18th centuries.

Around the same time as Van Beneden, another, and quite independent Russian tradition of biological mutualism was developing. In Tsarist Russia, the authorities, although wary of western materialism, did, for reasons of promoting the economic and industrial development of ‘backward Russia’, as well as military considerations (such as the exploration/mapping of Siberia and military medicine), generously funded their scientists, especially, in the areas of zoology, botany, physiology, geography and medicine. Following the Emancipation Act of 1861 there was something of an explosion in both the funding and interest in the biological sciences.

[231] The English translation of *Animal Parasites and Messmates* was published in London: Henry S. King, 1876.

Hence, Russia, prior to the publication of Darwin's Origin of Species (published in Russia in 1864), already had quite a number of gifted evolutionary theorists, most importantly the 'father of Russian botany', A. N. Beketov (1825-1902) and the Ichthyologist, K. F. Kessler (1815-1881). In virtue of their religious faith and moderate political outlook, these men had illustrious university careers and shaped the course of Russian biological science for several generations. They both taught in St. Petersburg where Kropotkin spent significant portions of his life.

The radical youth (the populists, to which Kropotkin also belonged) also included many social-scientific thinkers who had socialistic views upon evolution, most notably P.L. Lavrov (1823-1900), N.K. Mikhailovskii (1842-1904) and N.G. Chernyshevskii (1828-1889).

Darwin was warmly and enthusiastically welcomed by his Russian audience. However, the response was critical and adaptive. Elements of Darwin's thesis that stressed super-fecundity, over-population and intra-specific individualistic conflict were generally rejected. Struggle, as Darwin explicitly intended it should be, was interpreted in a broad way to include indirect and non-conflictual forms, particularly that of the organism struggling against a harsh environment. Intra-specific conflict, although emphasised by Darwin, was seen in Russia as secondary to inter-specific struggle. Many respected Russian commentators stressed the co-operative nature of animal societies/species in the struggle against predators and harsh environmental/climatic conditions. Although Darwin dealt with these approaches; fully exploring, at times in some very beautiful prose, the multi-dimensionality of his struggle metaphor; these passages are secondary to the central thrust of his thesis. Russians generally regarded Darwin's focus upon competition between individuals of the same species as resulting from nationalist and cultural bias. Darwin's emphasis on individualistic struggle was seen as typical of the British national character; an inevitable consequence of his class and upbringing. Darwin explained his metaphor of evolutionary struggle in 1859:

> "I use this term in a large and metaphorical sense…Two canine animals, in a state of dearth, may be truly said to struggle with each other which shall get food and live. But a plant on the edge of a desert is said to struggle for life against the drought…As the mistletoe is disseminated by birds, its existence depends on birds: and it may metaphorically be said to struggle with other fruit-bearing plants, in order to tempt birds to devour and thus disseminate its seeds rather than those of other plants. In these several senses, which pass into each other, I use for convenience sake the general term of struggle for existence."232

In virtue of the fact that Darwin and Wallace had formulated their theories in tropical countries, with dense or concentrated populations, Kropotkin believed they unintentionally over-emphasised the importance of intra-specific conflict. He claims that had they undertaken their researches in Siberia they might have formulated their theories differently:

> "Russian zoologists investigated enormous continental regions in the temperate zone, where the struggle of the species against natural obstacles (early frosts, violent snowstorms, floods, etc.) is more obvious; while Wallace and Darwin primarily studied the coastal zones of tropical lands, where overcrowding is more noticeable. In the continental regions that we visited there is a paucity of animal population; overcrowding is possible there, but only temporarily."233

Kropotkin like his fellow Russians rejected Malthusianism and argued that animals, in response to overcrowding or shortage of essential food/other resources, rather than engaging in conflict, either migrate to new places, or alter their modes of life to exploit new resources, thereby creating new niches and life-styles.

The Russian audience of whatever politics tended to differentiate between Darwin, and the social-Darwinists who focused entirely upon intense intra-specific conflict between individuals and interpreted Darwin's work in such terms.

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[232] Darwin, C., *The Origin of Species*, 1859 pages 62-3
[233] *Darwin Without Malthus* page 123.

Russia was a peasant economy with little industrialisation. The individualistic-capitalist culture in which Darwin was brought up simply did not exist in Russia. Conservatives or Monarchists (who wanted to benefit from western science but were hostile to western capitalist culture) tended to stress the reciprocal and co-operative nature of their feudal-social system.

The socialist and scientifically informed youth, who represented the alternative to Tsarism, likewise tended to place their hopes upon the natural co-operativeness of the Russian peasantry, and although embracing Darwin, rejected liberal-capitalist elements.

Kropotkin described himself in humble terms as a "simple traveller" following along the road behind "Kessler, Severtsov [an exceptional field worker and an orthodox follower of Darwin whom Kropotkin met and greatly admired], Menzbir, Brandt—four great Russian Zoologists, and a 5th lesser one Poliakov [a zoologist who accompanied and befriended Kropotkin in Siberia and with whom he worked closely] who stood against the Darwinist exaggeration of struggle within species".234 Kessler's main ideas235 differ little from those found in Kropotkin's Mutual Aid, and his general influence upon the subject matter of Kropotkin's study, for example, with regard to its focus upon zoology, to the almost total exclusion of botany and microbiology, are immediately apparent.

Daniel Todes who has studied Russia's mutual aid tradition with a good measure of common sense, intelligence and first-rate scholarship concludes:

> "Western readers will probably associate the theory of mutual aid with Kropotkin and his anarchist political philosophy. Kropotkin's view, however, were but one expression of a broad current in Russian evolutionary thought that pre-dated, indeed encouraged, his work on this subject and was by no means

[234] *Darwin Without Malthus* page 104.
[235] These are briefly and usefully summarised in *Darwin Without Malthus* pages 105-12.

confined to leftist thinkers. For Russians the seminal mutual aid theorist was a well established naturalist with centrist political views, K. F. Kessler, whose 1879 speech “On the Law of Mutual Aid” transformed a widespread sentiment into a coherent intellectual tradition...Kropotkin’s theory of mutual aid certainly had an ideological dimension, but it cannot be dismissed as the idiosyncratic product of an anarchist dabbling in biology....Mutual aid was not a controversial idea in Russia. Classical Darwinists there declined to attack it, nor did they associate Darwin’s theory with the “Social Darwinist” doctrines that were still popular in the West. It was only when Kropotkin brought a Russian intellectual tradition into contact with a quite different English one that he felt compelled to elaborate what for many Russians was commonsensical”236

Mutualistic reaction to social Darwinism also developed in Britain several years prior to the time when Kropotkin began writing Mutual Aid. Patrick Geddes, with whom Kropotkin corresponded, undertook pioneering work in the area of symbiosis, a decade before the publication of Mutual Aid. Around the same time as the first essays on Mutual Aid were published, Geddes and J. Arthur Thomson in their book, The Evolution of Sex (London: Walter Scott, 1889), argued:

“that the general progress of both the plant and animal worlds, and notably the great uplifts, must be viewed not simply in terms of individualism but very largely in terms of sex and parenthood, of family and association; and hence of gregarious flock and herd, co-operative packs, evolving tribes, and ultimately of civilised societies…The greatest step in organic nature, that between the single-celled animals and many celled animals...is not due to selection of the more individuated, but to the union of the cells into an aggregate whereby each becomes diminishingly competitive and increasingly subordinated to the social whole. The greatest of morphological steps was a process is not interpretable in terms of individual advantage…Each of the greater steps of progress is in fact associated with an increased measure of subordination of individual competition to reproductive or social ends, and of interspecific competition to co-operative association.”237

[236] *Darwin Without Malthus* pages 104 and 123. See also Todes, *Darwin’s Malthusian Metaphor and Russian Evolutionary Thought, 1859-1917*, Isis (78) 1987 pages 537-51, and Todes, *The Scientific Background of Kropotkin’s Mutual Aid*, The Raven, #6, 1993.

[237] Geddes and Thomson, Quoted in Jan Sapp, *Evolution by Association: A History of Symbiosis*, New York, Oxford University Press 1994, page 24.

In 1883, Kropotkin, “began to collect materials for further developing the idea, which Kessler had cursorily sketched in his lecture”, but which he “had not lived to develop” having died shortly after delivering it, in 1881.[238] It was though, T. H. Huxley’s essay, The Struggle for existence in Human Society, published in the Nineteenth Century journal in 1888, that prompted Kropotkin to write a long series of essays, by way of reply, in the same journal. These were later revised and eventually published as the book with which we are familiar today. Huxley portrayed animal life in terms of individualistic conflict, comparing it to a “gladiator’s show...whereby the strongest, the swiftest and the cunningest live to fight another day”. Early human society, in consequence “was a continual free fight, and beyond the limited and temporary relations of the family, the Hobbesian war of each against all was the normal state of existence”.

Mutual Aid was an immediate popular success as well as stimulating many evolutionary thinkers of the period to re-examine or appreciate the co-operative dimension of animal life and evolution.

Gould follows Odum in locating Kropotkin as the initiator of a social and biological debate as Kropotkin’s specific historical influence in the history of evolutionary biology and ecology (though his original work on the geology of Asia and climate change is another specific influence they fail to mention). It is significant that Gould correctly claims that Kropotkin ‘created’ a scientific juncture and initiated an ongoing debate in which Kropotkin is the central historical scientific figuer. Gould states: “Kropotkin created a dichotomy within the general notion of struggle—two forms with opposite import (1) organism against organism of the same species

[238] *Mutual Aid*, 1915 popular edition, page 3.

for limited resources leading to competition; and (2) organism against environment, leading to co-operation.”239

S. J. Gould, regarded Kropotkin as a having played a pivotal role in getting successive generations of biologists to appreciate “the second form of struggle—the style that Darwin called metaphorical and which pits organism against the harshness of surrounding physical environments, not against other members of the same species”. Gould concludes approvingly that, “the central logic of Kropotkin’s argument is simple, straightforward, and largely cogent”.

Mae-Wan Ho whose work focuses upon co-operation and the environment in genomic and biophysical processes, in a recent attack on Dawkins and E. O. Wilson (and the neo-darwinian tradition they represent) cites Kropotkin as both evidence and the founder of an alternative co-operative and mutualist tradition:

> “In the opening pages of his book E. O. Wilson gives the game away by posing the ‘fundamental’ and paradoxical (that is, paradoxical within neo-Darwinism) question of sociobiology: How could altruistic behaviour evolve, given that genes, and the behaviour they control, are fundamentally selfish? The paradox disappears, of course, when one rejects the assumption that selfishness or competitiveness is fundamental to the living world. Animals engage in competitiveness or aggressive acts, but that does not mean there are inherent qualities of competitiveness or aggressiveness which can account for those acts. Furthermore, examples of co-operation among animals far outstrip those of competition. Kropotkin argued that co-operation or mutual aid was much more important than competition in the evolution of animals and of our own species. He gave abundant evidence of the natural sociality of all animals which is independent of genetic relatedness. Animals, including human beings, simply enjoy society for its own sake. Thus, one could easily invert Wilson’s question and ask, why do animals compete, given their natural sociality?”240

[239] Gould, S. J., *Bully for Brontosaurus,* Hutchinson Radius, 1991, page 335
[240] Mae-Wan Ho, *Gentetic Engineering: Dream or Nightmare*, Bath (UK), 1988, page 100.

Mutual Aid Among The Animals

Kropotkin begins Mutual Aid by examining the social life of the “lowest animals”. Although, it was not possible yet to ascertain the true facts of the matter, he suggests that we “must be prepared to learn from the students of microscopical pond-life, facts of unconscious mutual support, even from the life of micro-organisms”.241

Recent studies of aquatic microbes have shown that, rather than competing individually amongst each other, do rather, from multi-species colonies in a wide variety of micro-niches, in which they “engage in rampant co-operation”:

> “Biofilms are thin layers of extracellular matrix secreted by the microbes which house a single species or multiple species of microbes. Biofilms are found coating solid surfaces in the environment—such as rocks and stones, gravel in the bottom of rivers, lakes and ponds, and the surfaces of aquatic plants. They may also be found in our gut and our circulatory system...Biofilms are structured communities living together. The cells are disposed in aggregates around water channels through which convection currents flow, so that nutrients and metabolites can circulate. In multi-species biofilms, mixed species micro-colonies are found where cells of metabolically cooperative species are juxtaposed so they can benefit from exchanging substrates and end products. The cells in a biofilm are effectively enjoying a kind of multi-cellular life served by a circulatory system. They are metabolically active but non-proliferating, just like most of the cells in our body”242

It is also worth noting that plants and animals are in reality multi-cellular complexes consisting of trillions of individual cells. So at least in one sense, all competition and co-operation between multi-cellular organisms, can be interpreted in terms group-selection.

Kroptokin discusses next the large periodic aggregations of cicadas. Though, again, he admits that the function or evolutionary rationale of the “numberless associations of cicadas has yet to be understood”243

[241] *Mutual Aid*, 1915 popular edition, page 17.

[242] Mae-Wan Ho, *Gentetic Engineering: Dream or Nightmare*, Bath (UK), Gateway Books, 1988, pages 228-9. Ho citess Costerton, J.W. (et. al) *Biofilms, the customised microniche*, Journal of Bacteriology, 176 (1994) 2173-242.

[243] *Mutual Aid*, 1915 popular edition, page 17.

The synchronised appearances of the periodical cicadas at intervals of 17 or 13 years is usefully explained by Wynne-Edwards in terms of the "predator-satiation hypothesis". The numbers are so great that the predators are completely swamped by them.244 The synchronised release of millions of individuals at the same time long intervals not corresponding to seasons, means that predators don't get to know when the cicadas are going to emerge and do not congregate seasonally to take advantage of them.

Kropotkin passes next to the Necrophorus beetles (literally bearing-dead). This beetle lays its eggs in the corpses of small dead animals which it must bury promptly in order that they do not decompose too rapidly:

> "They live an isolated life, but when one of them has discovered the corpse of a mouse or of a bird, which it hardly could manage to bury itself, it calls four, six or ten other beetles to perform the operation with united efforts; if necessary they transport the corpse to a suitable soft ground; and they bury it in a very considerate way, without quarrelling as to which of them will enjoy the privilege of laying its eggs in the buried corpse."245

Wynne-Edwards reports on recent research that not only confirms Kropotkin's observations, but, has revealed even more remarkable aspects to their ecology . The beetles carry (phoresy) a population of between 10 and 30 small mites that are attracted to them by a "dark brown fluid regurgitated by necrophorus":

> "In their quest for carrion to serve as larval food, the beetles have formidable competitors in the blowflies or bluebottles which lay eggs on exposed putrefying flesh. Springett found that when a beetle discovers and alights on a corpse, the mites it is carrying dismount, and rapidly search for blow fly eggs. Any they find are eaten immediately. Thus the mites keep the carcass free from the main competitors until it has been safely interred by the beetles...The individual beetle that finds the corpse is thought to signal by pheromone for help in burying it. After collaborators have assembled and finished doing this, dominance contests for possession follow, male versus male and female versus female. Finally the female is left alone to lay her eggs...When their larval offspring hatch they eat

[244] V. C. Wynne-Edwards, *Evolution Through Group Selection*, Oxford Blackwell Scientific Pubs., 1986, page 59.

[245] *Mutual Aid*, 1915 popular edition, pages 17-8.

the carcass. The female remains in the underground chamber with them and feeds them each time they moult, probably to re-inoculate them with digestive microbes. The mites reproduce at the same time, and their progeny emerge with the next crop of beetles…Under individual selection the finder would be expected to bury the corpse alone; and if conspecific competitors were to arrive before the task was finished he would have either to drive them off or give place to them. The second collaborative act is performed by the mites that provide a scavenger force of appropriate size...The fact that the corpse provides only a finite amount of food for the decomposers means that the life-cycles of any of these three principal actors—beetles, mites and blowflies—could come to grief unless each had in-groups that were capable of regulating their own reproductive rates."246

Kropotkin devotes many pages to the lives of social birds because "it is chiefly upon birds that we have the widest range of information".247 He discusses a number of well-documented examples of common collective behaviour among birds; collective fishing among pelicans; mobbing of eagles and other prey birds by lapwings etc; the use of scouts and sentinels by parrots; collective care of nests by Dotterels and social aspects of migration. After considering birds Kropotkin goes on to discuss similar social strategies and lifestyles among mammals, such as rodents, antelope, horses, bison, elephants and monkeys. It is concluded that the most intelligent, developed and successful animals in each class (ants among the insects, parrots among the birds and monkeys among the mammals) are all social. Kropotkin also argues that apart from the obvious survival benefits of animals having lookouts, collective hunting, flocking, mobbing etc., social life enables them to live longer and effectively regulate their populations, by bringing up fewer offspring but of better quality.248 Longevity, as Kropotkin suggests, among social animals allows for greater social complexity leading to useful social adaptations carrying significant survival-value.

[246] *Evolution Through Group Selection*, pages 323-5.
[247] *Ibid*, page 23.
[248] See for example his discussion of cranes, *Mutual Aid*, 1915 popular edition, page 30.

Although Kropotkin devotes many pages to mass aggregations (including mixed flocks and herds) with respect to migrations, his main stress is on the role of the group and its environment, rather than the species. Kropotkin, believed that many animals and birds live, at least for significant parts of the year, in structured communities and societies involving complex patterns of inter-personal interaction among animals that 'know' and 'recognise' one another. Although some animals do not live in this way, especially wandering opportunist carnivores like lynx, snowy owls or tigers, this is the exception, rather than the rule. Kropotkin makes note of this fact in Mutual Aid, when he observes that it is striking that there is an "overwhelming numerical predominance of social species over those few carnivores which do not associate."249 Thus, within most species, animals are not anonymous individuals unknown to one another except when conflicting, but engage in various forms of social behaviour, both competitive and co-operative, as a coherent group or population within a given habitat or neighbourhood. Kropotkin provides numerous examples including those of the "numerous packs of Black Bear of Kamtchatka" or the "compound families of elephants".250 Allee, under the influence of Kropotkin, as well as his own observations and the weight of evidence before him, came to very similar conclusions:

> "The growing weight of evidence indicates that animals are rarely solitary; that they are almost necessarily members of loosely integrated racial and inter-racial communities, in part woven together by environmental factors, and in part by mutual attraction between the individual members of different communities, no one of which can be affected without changing all the rest, at least to some slight extent."251

[249] Kropotkin, *Mutual Aid*, page 36.
[250] Kropotkin, *Mutual Aid*, pages 39 and 44 footnote. 1
[251] Ho, *Natural Being and Coherent Society* in *Gaia in Action*, Peter Bunyard (ed) UK, Floris Books, 1996 page 293

Kropotkin describes numerous examples of how economic co-operation in local groups or populations creates collective benefits, that may greatly enhance the survival of the individual, group and the species. Economic co-operation is used here in a broad way to describe the great variety of collective behaviour that is concerned with day-to-day survival and not directly concerned with reproduction, viz.: collective mechanisms for defence against predators (mobbing in birds), co-operative hunting behaviours (lions), group moderation of the environment (beavers), migration, hibernation (where the combined heat ensures survival), defence of feeding territories from competitors, etc. We shall shortly be examining in considerable detail the idea that economics play a central role in determining the advantages and dynamics of group or social behaviour in animals.

Society and Hierarchy

The crucial difference between Kropotkin and modern biologists whom follow in the mutual-aid tradition, is that: Whereas Kropotkin conceives animals living in an egalitarian commune, pact or community, other authorities extensively cited in this article, e.g. Edwards, Allee, Bonner etc., see intense (but often only at specific times of year e.g., nest building, mating etc.) individual competition between individuals in a group, leading to territorialism and social hierarchies. Innumerable and beautifully produced wildlife documentaries clearly show how animals establish territories, nesting sites, mates through social competition. Kropotkin was undoubtedly coloured in his observations by his belief in the commune as a natural focus for both human and animal life. In an early political article, an obituary of Darwin, published in 1882, he asserted that “Darwin and his successors comprise…an excellent argument to the effect that animal societies are best organized in the communist-anarchist manner."252

Thus one important criticism of Kropotkin's approach, is that many of the instances of social interaction which he describes in terms of social enjoyment, such as singing, dancing, chattering etc., are now more usually interpreted in terms of socially modified competition, though it is worth pointing out, that female birds of paradise and bower birds, which have a highly refined sense of colour, must clearly enjoy the dances or the artistic efforts of their male counterparts. Both Allee and Wynne Edwards argue that local or regional animal populations (in-groups or demes), by means of seasonally enacted displays or ritualised (and relatively harmless) contests etc, determine their sexual partners and regulate their breeding (and hence food supplies) through territorialisation or social hierarchies, without having to resort to continuous, bruising, draining and, perhaps, ultimately fatal, physical fighting. Although socially determined hierarchies and territories do not fit well with Kropotkin's theory of anarchist communism, they are nonetheless social mechanisms for avoiding unnecessary conflict, and are compatible with the central thrust of his thesis that animals have developed a wide variety of social behaviours for ensuring the provision of basic economic necessities, thereby avoiding potentially harmful physical conflict.

On the other hand, many naturalists, are in my opinion, all to ready to focus on competition to the exclusion of many non-functional truly gregarious aspects social life which, I believe, Kropotkin more fully appreciated. Kropotkin's insights on sociability and gregariousness are important because present day biologists, whose outlook is similar, like Wynne-Edwards, continually use overtly capitalist

[252] Kropotkin, *Charles Darwin*, Le Revolte, April 29, 1882, page 1.

terminology in their analysis; ‘property’, ‘tenure’, ‘rights’, ‘status’, ‘winners and losers’, and so on, without noting that the status or property rights of a successful grouse or alpha ape is based upon their strength, usefulness, health, fitness, fertility etc., and not upon inherited wealth and the chaos of individualist and corporate capitalism. Emphasising function and utility whilst using highly anthropocentric capitalist terminology leads some biologists to miss the significance of incidental non-functional aspects of social life. It is absurd to suggest that a litter of puppies are not playing, and that they are not enjoying doing so, even if practising for later more serious competitions.

It is usually assumed that social hierarchies and territorialism are the result of social behaviour rather than genetic factors. In the sense that it is the group, and not the genes, which determines which individual will gain the most advantageous position or territory. However, there are some interesting intermediate sorts of social hierarchy that have a stronger genetic component. Among long horn sheep, age dependant horn-size differences are used by the animals to predict dominance rank of their group and of strangers. For around eight years the horn grows and has a quite distinct shape with each year. This delay in somatic development in relation to sexual maturation, and the fact that juvenile behavioural traits are carried many years into adulthood, has led to the convincing suggestion that these social biological stages evolved neotenously. Later they were utilised socially. Neoteny, it has been suggested, is often triggered by overcrowding, and is a mutant extension of normal but poorly understood biological control mechanisms that delay sexual maturation, thereby controlling the size of the breeding population.253 In many species of

[253] S. J. Gould, *Ontogeny and Phylogeny*, Havard University Press, 1977, pages 346-8. Gould is drawing upon Geist, V. Mountain sheep: a study in behaviour and evolution, Chicago, Chicago University Press 1971.

‘higher’ vertebrates, including giraffes and African buffalo, appear to have created social hierarchies as a social adaptation of neotenous mutation events.254 This correlation between biological mutation and social adaptation has allowed animals to control their populations and conserve their environments. At least in some social mammals, therefore, age hierarchies, although partially socially adaptive, are the result of inherited biological mutations.

Although, the preceding considerations do not undermine Kropotkin’s Mutual Aid thesis, it is less kind to anarchist/non-hierarchical interpretations of animal behaviour, as it strongly suggests that societal hierarchies in mammals with extra-ordinarily long sexual maturation periods (which includes elephants, humans) has a strong biological element.

However, there is great variety of types of social hierarchy, ranging from very, very weak forms, which approach the anarchist-communist ideal, to rigid, top-down systems that resemble a fascist dictatorship. This range is observable in birds, larger mammals and primates. Allee, for example, compares the “absolute peck-right in chickens” with “peck dominance in pigeons”, where “the result of the next meeting between two individuals in not to be known with certainty until it has taken place”.255 In contrast, the peck order in chickens is based upon age and territory, where the young chicken inherits a fixed system at birth. Given enough space, many species of bird “even the lowliest in the social order dominate in some restricted space about their nest”256 Among canaries local dominance is the rule and “each bird becomes dominant in the region near its nest”.257 Allee further points out that many species domination of males or females may switch according to the (mating)

[254] Ibid, page 348.
[255] Allee, W. *The Social Life of Animals*, page 165.
[256] Allee, W. *The Social Life of Animals*, page 170.
[257] Ibid, page 167.

season. In mixed flocks, winter feeding groups in high altitudes, hierarchies are based on the size of members of the group.258 Thus hierarchies may be based on age and memory, size, territory, nesting site or gender. In flocking birds there is “often absence of definite leadership”259 much as in a human walking party the strongest might set the pace, whilst the ‘leader’ might be reading the map and setting the compass in the rear.

African baboons have rigid hierarchies structured by “one very dominant male with a harem” who exhibits “excessive dominance”. In contrast, South and Central American howler monkeys are, the “gentlest and most democratic of social animals”, where, “all wait their turn for sex”. Among howlers, it is difficult to discern whether there is one or more leader. Bonner speculates that, unlike baboons, howlers “live in a relatively easy environment”. Plenty of food and lack of predators may be the reason that the “dominance hierarchy is so weak”, and perhaps only needed to supply leadership/cohesion necessary for “direction” of the troop.260 Similar and quite striking differences in aggression and dominance can be observed between chimpanzees and bonobos, generally considered to be our nearest extant primate relatives. Eldredge, drawing upon the work of Wrangham, suggests that these differences are determined by the economics of their diet. The gentle bonobos have a much wider and more mixed diet that gives them a much more secure food source and involves less foraging competition.261 Humans, which show remarkable cultural diversity, often exhibit exactly the opposite social adaptations. Harsh conditions, more often than not, induce highly co-operative and peaceful human tribal groupings. Although it is tempting to draw comparisons between primate and

[258] Eldredge N. and Grene M., *Interactions: The Biological Context of Social Systems*, page 160.
[259] Allee, W. *The Social Life of Animals*, page 174.
[260] Bonner, *The Evolution of Complexity*, New Jersey, Princeton Uni Press, 1988, page 95.
[261] Eldredge N. and Grene M., *Interactions: The Biological Context of Social Systems*, page 156.

human cultures, the latter are really so diverse, that it really makes very little sense. Although leadership and hierarchy, upon the basis of ability, strength, age or gender, are a feature of all human societies, in terms of their political characterization they can range from direct democracy and egalitarianism, right through to quite rigidly and inflexibly structured tribal-monarchies. Thus the biological basis of hierarchy in humans is perhaps not very strong. It is however a definite element of all human systems and has biological origins, even if these are socially expressed in many and various ways.

Gene, Individual, Group or Species Selectionism:

Since Kropotkin's time four levels of selection have been elaborated by evolutionists and their relative merits widely discussed. These four levels are gene, individual, group and species selection. On the whole, species selection has been considered the most implausible, and group selection, only slightly less so. Individual and gene level selection is central to the neo-Darwinian synthesis and were championed for most of the 20th century by most biologists.

In mid 20th century ecology "Individual selection", was rejected. It was an "anathema to E. Odum's belief in highly structured ecosystems characterised by pervasive interdependence." Indeed, Odum, the experimental and theoretical ecologist historically most associated with the post WWII development of systems ecology, used "group selection as part of his explanation for ecosystem stability". 262 According to Odum, the evolution of stability or homeostasis in ecosystems, resulted from "a reduction in competition and an increase in mutualism." "The evolution of homeostasis and the consequent stability of ecosystems occurred

[262] Hagen, J., *An Entangled Bank: The Origins of Ecosystem Ecology*, New Jersey, Rutgers, 1992, page 161.

through a combination of group selection and co-evolution”263 Inherent in Odum’s analysis was functional language in which organisms “play functional roles” as “parts” of ecosystems.264 This notion of community generated “environmental homeostasis” was contrary to the theories of “individualist population biologists” such as Lack and Williams who, saw “populations as simply aggregations of individuals”.265 Lack and Williams argued that, “the recycling of nutrients to the plants in an ecosystem is not a function of decomposing bacteria; it is simply a fortuitous side effect of bacterial metabolism”. Apparently co-operative mechanisms, they argued, could similarly be explained in individualist terms, as for example, when animals huddled together for warmth: “each individual” is simply “insulating itself”.266 Thus “co-evolution can be explained in terms of individual selection, two individuals may co-operate, but each does so to increase its own individual fitness” as for example, symbiosis may develop from initial parasitism. “One cannot accuse E. Odum of vacillation or inconsistency. While most ecologists were turning against group selection, he rallied to its defence” As individualist population biology came to dominate biology and increasingly ecology during the course of the 1960’s, Odum just dropped this aspect of his thinking and accepted that “group selection type explanations were not necessary to explain the co-evolution of organisms in ecosystems.” 267 At the heart of “the group selection controversy was the nature of altruism”. The question is not “did animals contribute to the welfare of the group”, but did they also “sometimes” do so “in self-sacrificing ways”.268

[263] Ibid, page 129.
[264] Ibid, page 161.
[265] IHagen, J., *An Entangled Bank: The Origins of Ecosystem Ecology*, New Jersey, Rutgers, 1992, pages 154-5.
[266] Ibid, page 156.
[267] Ibid, page 161.
[268] Ibid, page 156.

Individual or Natural Selection

This describes the selection of individual organisms through competition with others of their species or an ability to survive in their environment. Individual or Natural selection was classically conceived as involving superfecundity, accidental/random useful variation and intra-specific conflict leading to the survival of those variations/adaptations that confer greater fitness. There is absolutely no doubt that the theory of natural selection explains certain processes at one particular level in the biological hierarchy.

Darwin thought that mutualist and group behaviour could be easily explained in terms of individual or natural selection, as have most Darwinians. The celebrated evolutionary philosopher G.J Romanes in his Darwin and after Darwin, states that Kropotkin had presented "a large and interesting body of facts showing the great prevalence of the principle of co-operation in organic nature". Romanes goes on to claim, however, that Kropotkin's examples "fall under the explanatory sweep of the Darwinian theory".269 Peter J. Bowler in his excellent study of evolutionary theory around the turn of the 19th century suggests that, although Mutual Aid was a welcome and timely challenge to the excesses of the social Darwinist school most Darwinians did not come to regard Kropotkin's mutual aid thesis as representing an alternative to the theory of natural selection.270

Gould has stated that the "consensus" may "perhaps be incorrect"271 with respect to a total rejection of group selection as conceived by Wynne Edwards. Gould does not however think that group selection represents a serious threat to

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[269] Romanes, G., *Darwin and after Darwin*, 3rd ed. (Chicago:Open Court 1901) page 269.

[270] Bowler, P.J., *The Eclipse of Darwinism*, Baltimore and London, J. Hopkins Uni Press, 1983, page 56.

[271] Gould., S. J., *Caring Groups And Selfish Genes*, in his book *The Panda's Thumb*, Harmondsworth, Penguin Books, 1983, page 75.

Darwinism, only the narrow or ultra Darwinism with which he has consistently taken issue. Like the majority of Darwinian's from Kropotkin's day to the present, Gould makes the point that it is not necessary to evoke group selection in addition to natural or individual selection to explain the evolution of co-operative behaviour:

> "Kropotkin committed a common conceptual error in failing to recognise that natural selection is an argument about advantages to individual organisms, however they may struggle. The result of struggle for existence may be co-operation rather than competition, but mutual aid must benefit individual organisms in Darwins's world of explanation. Kropotkin sometimes speaks of mutual aid as selected for the benefit of entire populations or species—a concept foreign to classic Darwinian logic. But Kropotkin also (and often) recognised that selection for mutual aid directly benefits each individual in its own struggle for personal success. Thus, if Kropotkin did not grasp the full implication of Darwin's basic argument, he did include the orthodox solution as his primary justification for mutual aid."272

Species Selection

Explanations of evolutionary change and stasis at the species level have generally been dismissed by evolutionary biologists in the recent past for the following two reasons. Firstly there has been a lack of intercourse between population biologists and palaeontologists, and secondly, attempts to understand species level processes did so with concepts borrowed from individual selection.

Palaeontology is a science based upon "analysing patterns of differential species births and deaths within monophyletic taxa through time." It is paleontologists that have "developed and debated species selection, simply because the data are at the proper scale" for undertaking such an analysis.273 Palaeontology and palaeo-ecology, beyond simply discovering and classifying the age and genealogy of fossil organisms and ecosystems, attempts also to provide explanations

[272] Gould, S. J., *Bully for Brontosaurus,* Hutchinson Radius, 1991, page 335
[273] Eldredge, *Macroevolutionary Dynamics,* page 138.

of why species and ecosystems come and go, as well as the rate at which they do so. Any such explanation will necessarily be at the species level.

Species Selection and Species Sorting:

To clear up the confusion resulting from attempts to explain speciation and extinction in terms of natural selection, palaeontologists have coined the term species sorting. Eldredge explains:

> "There is an important distinction to be drawn between species sorting, the general term for patterns of differential births and deaths of species within monophyletic taxa, and species selection, which however defined is a theory of causation underlying such sorting"274

The term species selection, coined in 1975, is accepted as a legitimate way to explain certain hypothetical processes resembling natural selection, such that, species are treated in the same way as an individual organism is, under the theory of natural selection. However, this approach to explaining differential species sorting is fraught with difficulties, most notably that a species is usually distributed in semi-isolated populations. Unlike populations of the same organisms, species do not interact with the world as unified entities; they lack "emergent properties" upon which selection can act. These ontological absurdities can, however, be overcome by considering such emergent species wide phenomena (to be discussed in considerably more detail below) as the Sexual Mating Recognition Pattern/System, that is unique to each species. This leads to the conclusion that "species selection is the proper analogue of sexual—as opposed to natural selection."275

Although there may be some reason to believe that species selection is useful in explaining certain instances of species sorting, the theory of punctuated equilibria reveals a fossil record of long periods of morphological calm interrupted by waves of

[274] Ibid, page 139.
[275] Eldredge, *Macroevolutionary Dynamics*, page 143.

differential ‘sortings’ of species. Thus species do not appear and disappear gradually, as conceived by natural selection, which rather suggests that non-adaptive mechanisms, such as geologically induced environmental change, plays a significant role in differential species sorting.

Attempts to explain species sorting almost certainly involve a multiplicity of evolutionary processes. It is really beyond the scope of this articl to debate the details of these ‘non-selectionist’ approaches to ‘among-species sorting’. Recent research has centred upon factors such as niche breadth and geographic range of a species in relation to genomic flexibility and environmental-geological change.

Gene Selection

In the last quarter of the 20th century, in part as a response to Wynne Edwards’ group selection theory, evolutionary biologists have attempted to re-hash the theory of natural selection in terms of competing genes. This sort of idea was first put forward by both Huxley and Spenser who both “extended the notion of natural selection to the microcosm of the individual organism”276. The idea that the individual is the result of competing elements is, however, most usually associated with the early and influential hereditary theorist, Weismann, of whom Kropotkin was a fierce opponent. In modern times the theory of genetic selection is associated with the ideas of Dawkins in his famous book, The Selfish Gene. In this work Dawkins argues that evolution is the result of fierce competition between selfish genes which seek to make as many copies of themselves as possible. Bodies are merely survival machines, programmed by the genes in which they are temporarily housed. This is a perversion of Darwin’s theory of natural selection, in that he regarded the unit of selection as the individual organism. The arguments for and against the thesis

[276] Hagen, J., *An Entangled Bank*, pages 3-4.

contained in Dawkins' book have been thoroughly debated and there is an exceedingly large body of scientific literature, and very many popular books in which his ideas are discussed. Perhaps the most serious objection is that, Dawkins' thesis is based upon an outdated, Weismannist viewpoint, which sees individual genes creating specific parts of the body. Such a viewpoint is clearly completely at odds with recent discoveries in genetics and developmental biology. Although genetic factors do play a major role in evolution, the notion of genetic competition/selection is of little use in explaining complex genomic processes which can only be characterised in terms of complex federative networks enmeshed in the organism of which they form a part. Even individual-selectionists who find the idea of group and species selection absurd, such as Maynard Smith, have stated that they think the genome evolved through symbiosis. At other sub-individual levels such as the relationship between different cells or organs, the idea that they are competing with one another, or evolved through competition, in my opinion carries little weight. It is intuitively more obvious thesis that multi-cellularity evolved as a result of co-operation and mutualism.

The other argument put forward by gene-seleletionists is the idea of 'inclusive fitness' or 'kin-selection'. This is the idea that apparently altruistic group behaviour can be more plausibly interpreted in terms of selfish strategies to pass on genes through closely related kin.

Group Selection

Darwin in his Decent of Man, first postulated the idea that the benefits provided to individuals through living in animal associations would most likely be favoured by natural selection. He also seems to suggest, though this is by no means clear that, it might perhaps be the case that animal associations could be considered as individual units of selection from the point of view of natural selection. In my opinion, although different groups may compete with one another for success in certain situations, the term group selection, like species-selection, should be restricted to this very narrow notion. However, what might more usefully be described as group-mechanisms, in which individual members are sorted into a variety of hierarchies or territories by the other members of the group, may have a significant role in evolution; though, I think, the term selection an inappropriate to describe these mechanisms. Groups, like species or genes, do not on the whole compete with one another in the way that individuals are conceived as doing so under the theory of natural selection. Consideration of group selection may be relevant, for example, where a particular group of a species, invents a new method of ensuring an adequate food supply, and greatly enhances the chances of the group's survival through passing this economically adaptive behaviour onto their young.

Wynne-Edwards' basic thesis is that social animals through means of hierarchies and territories regulate both their population and environment through a series of conventionalised contests that deny or give access to food, nesting sites and sexual partners. As Gould observes, this theory is at odds with neo-Darwinian concepts of individual selection as it requires that "many individuals limit or forgo their own reproduction for the good of their group."277

Wynne Edwards also argues that, animals and birds whose mating opportunities are regulated by the display of colourful or complex organs/appendages/devices, eg., combs, feathers, antlers, etc., which grow bigger or more elaborate in each successive year, may, over time, favour those individual which have survived longest, implying that they have genes that promote increased

[277] Gould., S. J., *Caring Groups And Selfish Genes*, page 73.

chances of survival in their progeny.278 The notion that group mediated sexual selection is unproblematically linked to an individual's economic success is however, highly controversial.

Natural and Sexual Selection

Darwin thought that economically advantageous adaptations were an important causal factor in determining reproductive success. However, he was "well aware that no straight, absolutely certain vector connected health and vigour with reproductive success."279 This is because of what he termed "sexual selection" among members of a local population. This concept describes the common situation where an ability to reproduce is determined by one or both partners upon the basis of often elaborate, but economically useless (and even detrimental), appendages or displays. The sexual preference of female Bower birds and birds of Paradise is decided by attraction to marvellously decorated nests and elaborate feathers. For Darwin, and in actual fact, "selection is a two step process" involving both natural and sexual selection. Thus, although "economics, determines to some degree what genetic information is passed on…there is also reproductive success that is not dependent upon relative economic success."280

Kropotkin does not refer to sexual selection in Mutual Aid, most probably as it is a side issue to his central thesis. Throughout Mutual Aid, Kropotkin takes it as given that economic success, especially with regard to group or communal co-operation, resulted in differential reproductive success among social species, when, for example, compared to solitary ones. Although prudery may have had some role to play in his tendency to ignore the complexities of sexual behaviour/preference with

[278] *Evolution Through Group Selection*, page 170.
[279] Eldredge N. and Grene M, *Interactions: The Biological Context of Social Systems*, page 61.
[280] Ibid, pages 63-6.

regard to reproductive success, a more charitable explanation is that this is consistent with the environmental or geographical bias of his general approach to the subject matter.

Ecology has traditionally focused upon the “economic behaviour of organisms in groups” whilst “evolutionary theory focused traditionally almost completely on the genealogical products”.[281] Kropotkin, as a geographer, as well as one of the co-founders of modern environmentalism, was particularly concerned to show how co-operative economic behaviour altered or improved the environment and survival chances of both the individual and the group or species to which it belonged.

Economic and Reproductive Hierarchies in Natural Organisation

In recent years it has become fashionable to talk of ‘levels of natural organisation’.[282] These have been usefully categorised into two hierarchies, the economic and reproductive, by Eldredge and Greene. Genealogical systems consist of “germline/genome, individual organisms, local demes, species and monophyletic taxa”. Economic or ecological hierarchies are composed of “individual organisms, local populations (avatars), local ecosystems and regional ecosystems.”[283] Modern palaeontologists suggest that a wide variety of different evolutionarily processes are acting, or acting in different ways, at different levels of the ecological and reproductive hierarchies. The processes that occur or typify different levels of the two hierarchies, all effect the evolution of life in their own way in combination with one another. Changes in genetic expression, chromosomal rearrangements, group

[281] Eldredge N. and Grene M, *Interactions: The Biological Context of Social Systems*, page 77.

[282] Wimsatt, W. C., *Reductionistic research strategies and their biases in the units of selection controversy*. In T. Nickles, ed., *Scientific Discovery: case studies*, Dordrecht, E Reidel, pp. 213-59

[283] Eldredge N. and Grene M, *Interactions: The Biological Context of Social Systems*, New York, Columbia University Press, 1992, page 4.

behaviour and environmental change may all impact upon evolutionary direction. There is a growing realisation that there are multiple inheritance systems and a multiplicity of different processes acting at different levels.

The Economics and Evolution of Innate Co-operation

The most important mutualist theorists after Kropotkin is the ecologist and biologist, W.C. Allee. Allee, although publishing the results of his experiments and research in the area of animal co-operation considerably more than half a century ago, remains relevant due his rigorous scientific method and the clear presentation of the results of his own simple, and well thought-out, laboratory experiments, as well as those of the many other pioneering scientists which he cites.

Allee is particularly noted for his work on the effects of under-crowding. This work was pioneering because within the history of the study of animal behaviour there has been any number of studies of the detrimental effects of over-crowding, whilst the literature upon the "ill effects of undercrowding"284 have been comparatively few. Allee noticed that, although animals have an "aversion to crowding", many animals maintain "dense crowds" during hibernation, breeding and migration.285 Allee describes many other instances where a "positive social reaction", involving crowding, can be induced experimentally. For example, a species of starfish that is normally widely dispersed in the wild "clump[s] together like magic" in a bucket of clear water.286 The existence of genealogically mixed flocks or schools of birds or fish, he points out, reveal that the "sexual-familial pattern" is "frequently, but not necessarily" the source of social behaviour and

[284] Allee, W. *The Social Life of Animals*, London, The Book Club, 1949, page 35.
[285] Ibid, page 18.
[53] Ibid, page 29.

appetite.287 Allee, drawing upon a series of simple laboratory experiments, proceeds to show why "mutual aid is innate through being inherently advantageous."288

Water fleas, housed in an aquarium, "condition" the water through giving of more carbon dioxide that "neutralises the alkali". In "many aquatic animals" "isolated animals consume more oxygen". Numbers "decreases the rate of respiration" making the individual organisms "more resistant to the action of relatively strong concentration of toxic materials". Planarian worms "crowded under the ultra-violet lamp so that they shade each other…are definitely protected".289 Allee terms such phenomena "mass effects", a term that can be relevantly applied to many aspects of "mass physiology". For example, sea urchin sperm in concentration "remain fertile" very much longer than "dilute suspensions." Allee also cites similar examples where the density of chemicals created by differing sized populations of young marine organisms may increase or decrease their rate of growth.290 Presumably sexual maturation is slower because the isolated animal senses chemically that there are no potential mates available. Both goldfish and water fleas feed eat more, and more frequently in the presence of others. This is due to the collective breaking down of the food source into small easily digestible particles. Allee concludes that, there is an "active acceleration of fundamental biological processes as a result of numbers…a sort of unconscious co-operation or automatic mutualism that extends far down among the simpler plants and animals".291 Experiments with baby mice reveal that, the lower nest temperature endured by "isolated young mice", rendered them "the most handicapped". Of more significance

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[287] Ibid, page 33.
[288] Allee, W. *The Social Life of Animals*, London, The Book Club, 1949, page 35.
[289] Ibid, pages 42-4.
[290]Allee, W. *The Social Life of Animals*, pages 52-66.
[291] Ibid, pages 68-9.

were cases where some of the mice "had lesions of the skin"; these were "quickly cured by the licking of their nest mates". Similarly, "regeneration of tails in certain fish grow back quicker due to increased salt levels created by the other fish which balances the osmotic tension at the cut surfaces favouring regrowth"292

Undercrowding also has detrimental effects upon birds and larger mammals. It is a well-known fact that small populations of endangered animals often fail to breed, or in the case of birds, may make nests but lay no eggs. There is, peculiar to each particular species a critical "minimum population which the species cannot go under with safety."293 Clearly, many, many animals feel security in numbers, either because of the protection, other economic benefits and deeper, perhaps genetically based mechanisms alerting individuals to the fact that their group is not viable without fresh genetic material from another group. Many sensitive endangered animals, such as some species of whale, have not increased in numbers despite bans on hunting them for many years.

Economic and Reproductive 'Causes' of Co-operation:

Kropotkin and Allee argue that the evolution and practice of co-operation among animals is about economics and day-to-day survival. This conflicts with the highly reductive genetic/reproductive explanations of co-operative behaviour that dominated mainstream biology for the last quarter of the 20th century. Dawkins' controversial book, *The Selfish Gene* has popularised the standard neo-darwinian Synthesis as elaborated by Fisher, Wright, Dobshansky etc. According to Dawkins' "reductive gene's-eye view….organisms have come to be regarded, at base, as being concerned exclusively with the maximization of reproductive success." Whereas Darwin had thought that, "offspring tend to inherit those features that confer relative

[292] Ibid, pages 80-4.
[293] Ibid, page 97.

economic success". Dawkins claims that, "all aspects of living systems are to be understood, ultimately, as an outgrowth of competition for reproductive success…That organisms actively seek to maximise their reproductive success". Whereas Darwin "saw natural selection as a simple accumulator". The Dawkinites:

> "see economic competition as a direct reflection of real competition for reproductive success…Natural selection is transformed from a passive accumulator to a dynamic process… responsible at bottom, for the organization of all manner of biotic entities: species, local ecosystems, and most of all, social systems. This reformulation of natural selection into active mode…in sociobiological literature maybe a downright perversion of the genuine evolutionary principle of natural selection" 294

Central to Dawkins' perspective is the notion of 'kin-selection' or 'inclusive fitness'. The idea that one's closest relatives contain a proportionately larger amount of the same genes. Hence, it is argued that, the individual's 'self'-interest to engage in co-operative behaviour with the group in order to ensure the survival of a higher percentage of its own genes. In this viewpoint "altruism" is considered as being "really a form of genetic selfishness":

> "Viewing co-operation solely as a form of competition obscures the plausible and certainly more simple alternative postulate: co-operation in social systems may be to the immediate economic advantage of the organisms, regardless of their degree of genetic relatedness…Organisms are no more about reproduction of genetic information…than they are purely matter-energy transfer machines…temporarily formed dissipative structures that happen to reproduce."295
>
> "At least in vertebrates, the actual organization of biotic systems—social systems in particular—should be read first and foremost as a simple, moment-by-moment maximization primarily of the economic lives of component organisms."296

[294] Eldredge N. and Grene M, *Interactions: The Biological Context of Social Systems*, page 5.
[295] Eldredge N. and Grene M, *Interactions: The Biological Context of Social Systems*, pages 148-9.
[296] Ibid, pages 143.

The reductionist-genetic-reproductive explanation of social behaviour makes sense with regard to social ants, But, is much less "applicable" to vertebrate societies, where mating patterns are often "cross-genealogical".297 Many animals have periods of dispersal, such as natal dispersal and mass migration.

Organisms are not sex-machines and devote most of their time simply to staying alive: foraging, hunting, burrowing, eating, breathing, respiring and excreting. Reproduction may only occupy a small amount of the organism's life, in maturity and in a quite specific season. More interestingly, animals, in response to their perception of the health of their economic resource base, may cease to reproduce at all.

Territories, Hierarchies and Resource Economics:

Social competition need not imply actual physical fighting (and often doesn't) and is usually restricted to specific periods. It may in fact, and Edwards argues that this is the case, that many contests, (rutting, leks, elaborate displays and dances) represent socially generated structured interactions involving pre-programmed rules/instincts of engagement and elaborate feed back systems, for co-operatively allocating and managing scarce economic resources (nest sites, food, cover, etc.) for the overall good of the group and the species. Without such mechanisms food may be come overtaxed or nesting sites overcrowded. Edwards believes that animals by means of territories and hierarchies, manage and conserve their food and habitat. Animals, in order to leave sufficient for themselves and the next generation, have to conserve and manage the environment, and that natural selection has acted powerfully in this direction, leading to the evolution of essentially (even if socially competitive) social mechanisms both within species and between

[297] Ibid, page 141.

them that, are capable of achieving this desirable end. Fruit-eating birds, whose food is often scattered unpredictably over a whole Forrest or region cannot defend territories. In order to conserve resources, Edwards argues, fruit-eaters compete for ‘traditional’ nesting sites in leks, but, often, feed in flocks. Pelicans, likewise, fish over a large indefensible area of shoreline along the edge of inland lakes and oceans, but guard their own nest site jealously. Kropotkin notes the “hunting and fishing association” among Pelicans in *Mutual Aid*:

> “They always go fishing in numerous bands, and after having chosen an appropriate bay, they form a wide half-circle in face of the shore, and narrow it by paddling towards the shore, catching all fish that happen to be enclosed in the circle. On narrow rivers and canals they even divide into two parties, each of which draws up on half-circle, and both paddle to meet each other, just as if two parties of men dragging two long nets should advance to capture all fish taken between the nets when both parties come to meet. As the night comes they fly to their resting-places—always the same for each flock—and no one has ever seen them fighting for the possession of either the bay or the resting-place.”298

Edwards, however, begs to differ with Kropotkin, and states that Pelicans within traditional resting-places will aggressively defend their spot if challenged by another. It may be the case that reduced fish stocks and coastal habitat destruction, since the time Kropotkin was writing have led to social behavioural adaptations leading to increased aggression. Edwards also mentions other birds, which Kropotkin uses, such as eagles, which often hunt for large carrion collectively over vast areas, but guard their traditional nesting sites jealously.

Insect and herbivorous birds rather than competing for nest-sites, engage in social competition over defendable territories. In either case Edwards argues, the goal is the same: to limit the population in a given region so that it matches food supplies.

[298] *Mutual Aid*, pages 26-7.

Edwards attributes the ability to self-regulate population to brain programming involving cybernetic feedback systems in the animal's brain that compute information relating to food supply, overcrowding, quality of food, over-exploitation etc., and respond accordingly by altering the size of their territories, laying more/less eggs, neglecting offspring, suppressed fertility etc. A study of Tawny Owls revealed, in a bad year none of "the entire population of 17-30 breeding pairs attempted to breed though they still occupied their territories."299 Similarly, "many species of vertebrates with steady populations have several years of adolescence before they attain sexual maturity, but, can shorten the period if circumstances require."300 Likewise some insects "can speed their progress towards maturity by omitting one or two larval instars in their development."301 Similar mechanisms can be observed in fish, in response to sustainable exploitation by humans. Chemo-reception in social insects, such as bees, through a "positive feedback mechanism, are able to regulate the relative numbers of the different castes."302 Parasites can evolve into symbionts, or at least regulate their population within the carrying capacity of the host. Bacterial symbionts are able to reproduce at rates which far exceed the growth rate of their hosts, yet, harmony is attained. Edwards reviews literature which shows that, tapeworms through chemical signals and other methods appear to suppress free-living populations of larvae in surrounding waters if the majority of a population of ducks are infected.303

In an exhaustive and elaborate series of field experiments with red grouse in the heather moors of Scotland, involving the fertilisation of different or different

[299] *Group Selection*, page 20.
[300] Ibid, page 30.
[301] Ibid, page 31.
[302] Bonner, *The Evolution of Complexity*, New Jersey, Princeton Uni Press, 1988, page 159.
[303] *Group Selection*, chapter 18.

sections of moors, the removal of dominant birds from their territories (by shooting them), and many other related empirical investigations, Edwards attempts to show how they alter the size of their territories in direct response to their perception of the food supply (in a harsh environment). Animals that fail to get a territory are expelled from the moors (presumably into adjacent land without cover) and become easy prey for predators, who would stand little chance (and hardly worth the energy expended if they did) of catching the grouse in middle of the moor.

> "The red grouse expel a large surplus from their populations each autumn, but do not actually kill them. Instead the predators conveniently find the outcasts easier to catch than birds securely established on their territories; and in effect they provide the established grouse with a useful clean-up service. They do not directly control the grouse population. The controlling is normally all done by the grouse themselves through social competition, which selects how many and which individuals are to exposed to risk before the predation actually takes place. The discovery of what is very likely a common relationship between predators and their prey gives one a new insight into interspecific mutualism, as far as predators are concerned."304

This seems individualistic, territorial and anti-social, But, during the summer months when food is plentiful grouse give up their territories. Moreover, at any time of the year "in the presence of a golden eagle" they "often pack into flocks for safety and these occasionally contain a few hundred individuals."305

In support of his thesis Edward presents a large number of examples of behaviour that are difficult to interpret in terms of maximising individual advantage. One good example are birds that live in symbiotic/mutualistic relationships with mistletoe. Mistletoe is slow growing. The time-delay involved in receiving the benefits of planting the seeds upon suitable trees, cannot be explained in terms of individual selection:

[304] *Group Selection*, pages 38-9.
[305] Ibid, page 173.

> “The delay between depositing the seed and harvesting the crop, plus the life span of the plant, may be long enough to prevent the individual donors receiving much direct benefit from their actions. If one has to accept the prospect of non-co-operators reaping much of the rewards, the premises of individual selection break down, and one is thrown back on group selection to explain how the mutualism could have evolved and be sustained. Birds that sow food plants for future use are simply carrying the practice of resource conservation a step further beyond the minimum, and it is predictable that the indirect benefits in fitness, if any, will as a rule, accrue to succeeding generations of the same structured deme.”306

Edwards suggests that social or group adaptations, group population regulation and philopatry (the tendency towards staying in a particular territory, returning to the same nesting or breeding site, as in salmon and migratory birds) may have a genetically useful component. Information about how to maintain ecosystems optimally can be passed to the next generation. Local populations integrated within a particular environment, benefit from the “fruit of accumulated collective experience”.307 Edwards suggests that, group adaptation to the environment offers economic/survival advantages that individual selection cannot deliver:

> “The behavioural world...is in fact the social world. It appears in part to provide a kind of theatrical stage, or make-believe way of life, where individuals play instructed parts, instead of being tossed out into a free-for-all in the rough world outside. Nevertheless it is a competitive world and the struggle for existence remains keen; but the members of social groups co-operate in civilizing it and, so far as the competition is concerned, they enact it according to rules. Everything the social code decrees is done for the common good, and it is typical that the rules for social competition virtually eliminate bloodshed in the pursuit of personal advantage. After describing a lek, it is needless to say that social competition is conventionalised; and the prizes the competitors seek are equally artificial substitutes for the true requisites of life. In a lek the males are contesting for position and status. Those that emerge at the top, holding the highest rank and the best sites, will later engage in reproduction, while the rest will be inhibited. The social code is absolute and binding. It applies in exactly the way to food as it does for reproduction...The fitness they enjoy are far higher than those attainable by a population of independent non-co-operators, exploiting similar habitats for personal gain without regard to the

[306] *Group Selection*, page 322.
[307] *Mutual Aid*, page 35.

consequences...Co-operators [are] able to hand on to their successors well cared-for, productive habitats, the freeloaders would be unable to prevent their own numbers and conflicts from escalating, with the result that their habitats would be stripped of renewable assets in a ruthless pursuit of personal fitness...cooperative populations in well-conserved habitats would speedily and easily attain higher mean fitnesses than self-seeking individualist could maintain."308

Although it has been the practice to treat complex social behaviour, such as territorialism, as an adjunct of reproduction, Edwards shows that, it is very much about economics as well. In times of economic stress, reproduction is often the first thing to be sacrificed. "Reproduction costs energy…and is inessential to an organism's life". Human "reproductive dysfunction results from general somatic stress" as can be ascertained from the "disruption of menstrual cycles in women athletes undergoing intensive, rigorous training."309

Just as ecosystems are about cross-genealogical economic relationships, the evolution of the nucleated cell through symbiosis of various types of free-living bacteria is about the amalgamation of various economic abilities to form a functioning whole.310 Similarly "mixed species flocks" and other "cross-genealogical" economic "aggregations, exemplify the importance that economics per se has in the structure of any social system".311 A good example is that of mixed communities upon coral reefs:

"On the Barrier Reef the branching coral *Pocillopora damicornis* harbours up to 16 species of crustaceans and fish that use the coral for food and shelter. Close study of the most conspicuous residents, two fish, a crab and a shrimp, showed that although they have the potential to harass, capture or exclude one another form the coral, a system of signals among the residents facilitates coexistence. The pistol-shrimp, *Alpheus lottini*, uses it legs to scratch the hairy hind surfaces of the claws of the small xanthid crab, *Trapezia cymodoce*…The two fish

[308] *Group Selection*, pages 9-13 passim.
[309] Eldredge N. and Grene M, *Interactions: The Biological Context of Social Systems*, page 62.
[310] Ibid, page 71.
[311] Eldredge N. and Grene M, *Interactions: The Biological Context of Social Systems*, pages 159.

undergo shivering movements when in close contact with the shrimp or crab, thereby preventing aggression from the crustaceans. Experiments showed that non-resident fish fled from approaching crabs, which became extremely aggressive and snapped at the fish. Newly colonising fish have to out-manoeuvre the crustaceans among the coral branches until the signal system is learned…Each member of the established team benefits by the presence of the others because the effort of defending the coral head against predators or competitors is shared. All inhabitants feed on coral mucus or tissue, and the repulsion of competitors may keep the number of residents at a level that is not detrimental to the food supply."312

Life cannot be reduced to reproductive or genetic forces. The economic benefits of optimally sized local populations, whether they be simple aggregations or complex social groups, are, as Kropotkin, Allee, Eldredge, Greene313 and Edwards assert, integral to any balanced explanation of social and group behaviour among animals. "Among primates" there is a "strong emphasis on economic activity"314 in relation to their social structuring.

Unlike late twentieth century biological philosophers, Kropotkin did not have sex and reproduction on the brain. Kropotkin's account of mutual-aid in terms of largely economic factors, provides a useful social-economic-political and biological counterbalance to this unfortunate trend.

Destruction of Habitat, Over-Hunting Effects Population Size/Distribution and Changes Animal Behaviour

Another interesting theme of *Mutual Aid*, which again has a strong environmental dimension, is Kropotkin's observations upon the destruction of animal culture or society because of human exploitation. Kropotkin repeatedly argues that many animals, that now live solitary or socially competitive lifestyles, were social,

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[312] Barnes, R., and Hughes, R., *Introduction to Marine Ecology*, 2nd Ed., Oxford, Blackwell, page 191.

[313] See Green and Eldredges remarks on the Florida Shrub Jay in *Biological Context.*

[314] Eldredge N. and Grene M, *Interactions: The Biological Context of Social Systems*, page 155.

before the invasion and fragmentation of their territories by humans.[315] This is an important theme. Herman Melville, for example, in *Moby Dick* (which is as much a documentary of whales and whaling as it is a story) tells of huge congregations of whales swimming in vast circles at certain times of the year. Less dramatically, increased competition/aggression among birds for securing nesting sites, where most tall trees have been felled by humans, is one example, of many, that *does* affect animal behaviour.

As noted in the introduction, the term ecology was used interchangeably with ethology at the beginning of 20th century, and that at this time “the idea that animal behaviour could be understood by close observation in the wild was a radical idea”.[316] Kropotkin, throughout *Mutual Aid* champions the need for adventurous field studies in the wilderness and derides the idea that laboratory or desk-top biology is of much use in the scientific study of animal behaviour within their natural environment.

Sociality, Intelligence and Survival

Kropotkin argues that intelligence is directly attributable to sociality and leads to much greater survival chances. He maintains that: "intelligence is an eminently social faculty",[317] and those species which "show the greatest development...of sociability lead first of all...to the better development of the mental faculties".[318] "Language, imitation and accumulated experience are so many elements of growing intelligence of which the unsociable animal is deprived."[319] Although

[315] *Mutual Aid*, 1915 popular edition page 24 (foxes, wolves and eagles), 37 (weasels).
[316] Bramwell, A., *Ecology in the 20th Century: A History*, page 41.
[317] Kropotkin, *Mutual Aid*, page 50.
[318] Kropotkin, *Ethics, Origin and Development*, Tudor Publishing Co.,1947, page 321.
[319] Kropotkin, *Mutual Aid*, page 50.

there certainly are intelligent animals who are not particularly social, such as octopuses, this is the exception rather than the rule. As highly developed intelligence is often cited as being the most important factor in the human species' evolutionary success we ascribe much greater significance to sociability in human development and human evolutionary theory generally. The contemporary philosopher Mary Midgley, makes a similar point in her book *Beast & Man*:

> “There might, perhaps, have been an intelligent species somewhere which did not develop direct social impulses at all, but depended for all its social activity on calculation of consequences. We are not it. It would have done many of the things we do, but for quite different reasons. Others it not only would never have done, but could never have understood at all. But it is this alien species that is demanded by people who think of intelligence as the source of all social development...If intelligence had really been the only impelling force (towards sociability and co-operation) most of the concomitants would never have been found necessary. Why affection? why time-consuming greeting procedures, mutual grooming, dominance and submission displays, territorial boasting, and ritual conflict? Why play? Why (on the human scene) so much time spent in non-productive communication of every kind - idle chatter, lovemaking, sport, laughter, song, dance and story telling, quarrels, ceremonial mourning and weeping. Intelligence alone would not generate these ends. It would just calculate means. But these things are done for their own sake; they are a part of the activity that goes to make up the life proper to each species. Insofar as there is one 'impelling' force, it is sociability. From that comes increasing power of communication, which provides the matrix for intelligence.”[320]

The relationship between group behaviour and the development of intelligence was also a major interest of Allee, who conducted a series of experiments with cockroaches and fish in mazes. With regard to minnows and cockroaches, which are not very social, learning ability was generally poor. The extra individuals, in many cases, causing confusion. In other, more recent experiments, which we will discuss later, concerning the intelligence and learning ability of social

[320]Midgely, M., *Beast and Man*, London, Methuen, 1980, page 130.

insects such as ants, it has been shown that they are as good at solving mazes as rats, only that they accomplish the task somewhat slower. Allee's own experiments were with goldfish, which naturally swim around in small cohesive groups. Goldfish which were allowed to live in a small group, or where an especially trained fish was introduced, showed increased speed of learning. "Grouped fish learned more rapidly in the presence of a leader, which others could copy by imitation at a relatively simple instinctive level through watching the reaction of their trained fellows."[321]

Though we shall be examining in some detail later the reasons why there has been strong selective pressure for the non-genetic transmission of information, I shall briefly outline some of the main points. Geographical information (such as that necessary for migration or location of food sources) or information regarding which predators to avoid (which can change over time) are difficult to encode for genetically. Thus there are strong economic pressures that led to the development of social behaviours, such as imitation, communication, learning and teaching. The ability instantaneously to communicate the existence of a new predator, food source etc., has obvious economic or survival values. Thus not only is social life a major source of intelligence in animal life, but the need for instantaneous, flexible or novel responses which can be passed on immediately by non-genetic means, has meant that there have been strong selective forces in favour of the development of the brain. Selective pressure for intelligence also exerts pressure for social living which is its nursery.

[321] Allee, W. *The Social Life of Animals*, page 147.

Functional and Non-functional Sociality

In addition to the economic and other benefits of social life, Kropotkin is also keen to point out, that for many animals, social life is pleasurable, bringing new sources of enjoyment to animals, and leading to the rudimentary development of compassion and a moral sense of justice.[322]

Throughout *Mutual Aid* Kropotkin makes a clear distinction between the evolutionary or survival functions of *co-operation* or *mutual aid* and the related concepts of *sociability* or *association*. Sociability and social relationships can be functional as well as non-functional. Although Allee does not develop the idea further, he also makes a similar point. The "existence of a widespread, fundamental automatic co-operation which has survival value", he claims, can be differentiated from "group behaviour which may or may not have immediate survival value"[323] He continues:

> "Reactions may be regarded as social in nature to the extent that they differ from those that would be given if the animals were alone…Social behavior may have or may lack positive survival value. All that is necessary is that the behavior be different from that which would be given if the animal were solitary…Cockroaches, fishes, birds and rats shows evidence of distinct behavioral modification as a result of more than one being present."[324]

Although co-operative economic practices can in many instances serve as an evolutionary stable strategy and thereby increase the survival chances of the individual and species, a proportion of the social behaviour observable in nature has no obvious survival function. Certain species of starfish, it has been found, are remarkably social. Speeded-up film shows them to be constantly caressing, touching and lying on top of one another. Such activity appears to have no obvious function

[322] *Mutual Aid*, 1915 popular edition pages 46-51.
[323] Allee, W., *The Social Life of Animals*, page 112.
[324] Ibid, page 150.

whatsoever. The European Blackbird, on the other hand, although giving out warning calls upon the approach of predators, and thereby teaching others which predators to avoid as well, are individualistic and territorial creatures who do not live within a societal framework. Here we observe practices which benefit both the individual and the species and carry an obvious survival function, but which are not undertaken in a social manner. Similarly, many ritualised contests, that are functional and socially competitive, such as between competing male birds in leks, are social but not gregarious. For this reason the distinction which Kropotkin draws between "sociability" or "society for society's sake" and functional mutual aid practices is an important one. Society and sociability are in many cases not imposed through evolutionary necessity but are also cultivated for their own sake. Animals do not engage in social activities merely to fulfil some limited and self-interested purpose, such as reciprocally removing ticks from hard-to-reach places, but because social life is enjoyable and pleasurable in its own right. In Kropotkin's words:

> "...[I]t is extremely difficult to say what brings animals together - the needs of mutual protection, *or* simply the pleasure of feeling surrounded by their congeners...sociable life is maintained notwithstanding the quarrelsome or otherwise egoistic inclinations of the isolated individual. Thus *it is not imposed* as is the case with ants and bees, by the very physiological structure of the individuals; it is *cultivated* for the benefits of aid *or* for the sake of its pleasures...Sociability - that is, the need of the animal of associating with its like...only now begins to receive due attention from zoologists...the necessity of communicating impressions, of playing, of chattering, or of simply feeling the proximity of other kindred living beings pervades Nature, was and is, as much as any other physiological function, a distinctive feature of life and impressionability. This need takes a higher development and attains a more beautiful expression in mammals...becoming—in short, a manifestation of *sociability proper*, which is a distinctive feature of all the animal world."[325]

[325]Kropotkin, *Mutual Aid,* pages 41, 47-8. My emphasis.

Kropotkin's observations have important consequences for individualistic explanations of co-operative behaviour amongst animals. There have been, literally, thousands of academic articles, in recent years, that argue that although animals do engage in co-operative practices, such behaviour always carries with it a survival function and, as such, is beneficial to the agent and therefore ultimately selfish. This argument, is frequently made by sociobiologists, who argue that, because we are "programmed" by our genes to preserve them, any social activity which we engage in is, by definition, designed to favour the survival of our genes, and therefore reducible to self-interest (albeit the self-interest of the gene!) Such accounts, however, gain their initial plausibility by reducing everything to the abstract level of the gene, thereby eliminating all non-functional "sociability" from their calculations at the outset. But many animals have emotional and psychological needs or predispositions that, in many instances, require a social structure in which they can be exercised and fulfilled. We cannot explain many social activities that we engage in, such as playing bridge, cuddling pussycats or singing in a choir, as a function of gene survival.

Mutualism and the Evolution of Multicellularity

Symbiosis and symbiogenesis were responsible for the evolution of the nucleated cell and coral reefs. But, these evolutionary processes cannot explain the evolution of multicellular organisms or animal and human societies. Like-cells co-operate with one another to form progressively larger social wholes, and in the realm of larger multicellular organisms, the development of groups and societies. These are often explainedby sociobiologists in terms of kin-selection. The idea that, because youv’e got similar genes to your relatives, group or tribe, protecting and caring for them is ultimately selfish, because, you are looking after your own genetic stock. But the sophistry of the selfish gene hypothesis is, in the opinion of a growing minority of biologists inadequate. The evolution of multicellularity is more plausibly explained in terms of Mutual aid (mugenesis[326]). Neither Symbiosis nor conflictual individualism can explain the evolution of mutualist relationships between related cells within living organisms. In multicellular eukaryotes cells differentiate, but their genomes are almost identical (though mitosis does not result in identical cells) within the individual and the species:

> "All the cells of a plant or animal body have the *same* genetic information, but cells are differentiated because different genes are switched on in different cells. An epigenetic inheritance system is involved because cells of a given type usually reproduce their own kind, This does not usually depend on differences in the DNA sequence, but on replicable states of activation...Formally, the development of an insect colony resembles epigenetic development...Epigenesis [leads to] an increase in complexity, as exemplified by multicellular organisms and insect societies"[327]

Complex organisms evolve when genomically very similar cells perform different functions within a multicellular whole. By means of somatic memory and mutualism epigenetic inheritance systems are able surpass (and infinitely so in relative terms) a presumably initial stage of a simple aggregation or colony of identical and undifferentiated though related cells:

> "An important property of an integrated multicellular organism is that it maintains its coherence despite turnover of the component cells. Cells divide and die, yet the organism retains its identity and functional integrity. In other words, the system is more enduring than its component parts. The maintenance of this coherence in the face of constant cell turnover means that newly produced cells must be similar to the cells they replace. It is the Epigenetic Inheritance systems that make it possible for organisms to survive longer than the life span of their component cells. Epigenetic inheritance systems thus enable the evolution of a new unit of function, the cell lineage..."[328]

[326] This is a term of my own invention

[327] John Maynard Smith, A Darwinian View of Symbiosis, Symbiosis as a Source of Evolutionary Innovation, page 32.

[328] Jablonka and Lamb, page 205.

> "EISs underlie cell memory. It is the EISs that ensure that when a kidney cell divides it gives rise to kidney cells."[329]

Aristotle, who wrote more upon biology than any other subject, first used the term epigenesis to describe, the fact that,"embryonic development appeared to be a number of separate genesises beyond the original genesis. Except for a brief period when the anti-Aristotlean theory of preformism was fashionable natural philosophers have, generally accepted Aristotle's characterization of embryonic processes. According to the 18th and early 19th century conception of preformationism the embryo is conceived as simply growing larger from a performed exact miniature like the well-known Russian mother-baby dolls. Whereas, Aristotle maintained embryonic development involves the "genesis of new structures and not a simple growth of pre-existing structures."[330]

> "Even in bacteria the genome does not contain a complete description of the cell, but only the linear information of its polypetides, each of which acquires a three-dimensional form with an assembly process that is not written in the genes."[331]
> "The enormous amount of information which is stored in the three dimensional structure of a cell comes from a chain of epigenetic assembly processes that do not just simply take place after the expression the genes, but also because new properties emerge in stages very much like the way in which novelties appear in embryonic development." "Genes intervene only at the very beginning when they are copied into primary transcripts of RNA. From this point onward, all other body construction steps take place in the absence of genes, and are collectively known as epigenetic processes."[332]

Although early evolutionary thinkers, such as Haeckel thought of organisms in terms of a "cell state", for most of the twentieth century the unit of evolution was thought of as the multicellular individual. This focus changed in the last quarter of that century, in part, because of the popularity of the notion of the gene as being the only significant unit of selection. This change in emphasis followed the publication

[329] Ibid, page 80.
[330] Barbieri M., *The Organic Codes*, Cambridge University Press, 2003, page 24
[331] Barbieri M., *The Organic Codes*, page 31
[332]Barbieri M., *The Organic Codes*, page 99

of Dawkins' famous book, *The Selfish Gene*[333], in which the organism is conceived as simply a 'vehicle' for replicating the selfish genes within it. Developmental biologists these days, although acknowledging the value of some of Dawkin's ideas, talk rather in terms of natural selection acting upon *all* organisational/information/developmental levels, the individual genes, the positioning of the chromosomes within genomes, the intra-cellular organelles, between cells and cell-lineages, between individuals, species, societies and the ecosystems which house them. Selection is conceived as acting not only upon individuals in the external environment but also in the within-individual environments, between somatic/germinal cell lineages, cytoplasmic organelles and genes.

In actual fact this basic idea was not originated by Dawkins, but by Weismann. Weismann conceived cells and their determinants as competing for success within individuals, for example, in so-called "germinal selection", where the germ cells, or more correctly "the determinants of the germ-plasm" were thought to "struggle" or compete for reproductive success.[334] Indeed Weismann, thought that his idea that "the principle of selection rules over all the categories of vital units...would endure if everything else [in my works] should prove transient".[335] Kropotkin, in *Evolution and Environment*, attributes Weismann's inspiration for this notion to the works of W. Roux, who had previously entertained the idea that there might be "conflicting claims of the different organs upon the available stock of nutritive stuffs in the organism".[336] Weismann, Kropotkin claims, simply transferred

[333] Dawkins, R. *The Selfish Gene*, Oxford University Press, 1976.

[334] Kropotkin, *Evolution and Environment*, page 201.

[335] Weismann, quoted in Buss, L., *The Evolution of Individuality*, New Jersey, Princeton University Press, 1987.

[336] Kropotkin, *Evolution and Environment*, page 201.

Roux's idea in his attempt to explain observed evidence of "inherited modifications" as resulting from a "struggle for food between the determinants of the germ plasm."[337] Kropotkin dismisses this idea as a hypothetical oversimplification little worthy of further attention. He concludes that, Weismann's use of the term "struggle" with respect to within-individual interaction was "a metaphoric expression for processes far more complex in reality"[338]

Kropotkin does not criticise Weismann's ideas on intra-individual struggle or competition in any more detail. However, in a couple of passages from two of his popular anarchist political pamphlets, he talks of an individual as being the result of (his favoured political concepts of) self-regulation, association and federative co-operation at cellular and subcellular levels leading to larger and more complex organisms that are better able to survive the exigencies of a hostile environment:

> "Without solidarity of the individual with the species, the animal kingdom would never have developed or reached its present perfection. The most advanced being upon earth would still be one of those tiny specks swimming in the water and scarcely perceptible under a microscope. Would even this exist? For are not the earliest aggregations of cellules themselves an instance of association in the struggle."[339]
>
> "When a physiologist speaks now of the life of a plant or of an animal, he sees an agglomeration, a colony of millions of separate individuals rather than a personality, one and indivisible. He speaks of a federation of digestive, sensual, nervous organs, all very intimately connected with one another, each feeling the consequence of the well-being or indisposition of each, but each living its own life. Each organ, each part of an organ in its turn is composed of independent cellules which associate to struggle against conditions unfavourable to their existence. The individual is quite a world of federations, a whole universe in itself. And in this world of aggregated beings the physiologist sees the autonomous cells of blood, of the tissues, of the nerve centres; he recognises the millions of white corpuscles who wend their way to the parts of the body

[337] Kropotkin, *The Direct Action Of Environment And Evolution*, The Nineteenth Century And After Vol 85 (1919), page 77.

[338] Kropotkin, *Evolution and Environment*, page 201.

[339] Kropotkin, "Anarchist Morality", *Revolutionary Pamphlets* (ed. Baldwin), page 97.

> infected by microbes in order to give battle to the invaders. *More than that: in each microscopic cell he discovers today a world of autonomous organisms, each of which lives its own life, looks for well-being for itself and attains it by grouping and associating itself with others*. In short, each individual is a cosmos of organs, each organ is a cosmos of cells, each cell is a cosmos of infinitely small ones. And in this complex world, the well-being of the whole depends entirely on the sum of well-being enjoyed by each of the least microscopic particles of organised matter. A whole revolution is thus produced in the philosophy of life."[340]

Although similar conceptions were embraced by Haeckel and later utilised by fascist thinkers, Kropotkin's account lacks the hierarchical elements of Haeckel's thinking. Kropotkin's account of cellular and subcellular evolution, organisation and development, unlike Weismann's and Dawkin's centralist and competitive one is, a mutualistic, co-operative, decentralised and federative. The determinants of cells, the organelles of cells and the cells themselves joined forces at an early period in evolution to form social collectives which through mutualism and federation led to the development of large multicellular organisms.

A Human adult consists of some 75 trillion cells, perhaps of around 500 different lineages, most of which most of the time appear to co-operate for the good of the individual in which they live and of which they form a part. Moreover, each cell consists of numerous autonomous parts that, somehow come to live in harmony with one another. Beneath this level we find the chromosome and eventually through a succession of different levels we come to individual genes. At the other end of things we find individuals organised into groups or societies, as well as species, which are in turn part of ecosystems, and so on. Thus life is conceived in what contemporary biologists and palaeontologists call the 'hierarchical' view of nature.

[340] Kropotkin, "Anarchism: Its Philosophy and Ideal", *Revolutionary Pamphlets* (ed. Baldwin), pages 118-9.

Hierarchy in this sense should be differentiated from the political notion. In the biological sense it simply depicts a series of levels, where there is no one-way of uni-directional flow of information or control. The question: of what level--the gene, the individual or the ecosystem, controls the evolution, development and maintenance of life, is misplaced. Surely, rather, each level have their functions in the organisation and replication of life, though higher levels are dependant upon the smooth running of lower ones. Life has progressively attained greater complexity through increasing stability, integration and organisation at lower levels generating novel levels of organisation above.

Weismann's and Dawkin's conception of centralized hierarchical control and instruction from the genes (from the bottom up if you mean from small to big and from the top down if you mean that information is power) view organismal development as a process controlled by genes involving a one way flow of information and instructions. Whether centralized and hierarchical control is an essential aspect of the competitive/selfish metaphor or biological paradigm (and the new genetics suggests that this paradigm is empirically false) it is certainly an integral part of an historic tradition in liberal science and politics which traditionally sees the state (centralized control of information and authority) and capitalism (individual competition) as necessary, essential, complimentary or a cause of one another. Selfishness and competition generates efficiency, robustness, freedom, innovation, etc. But, requires and generates a structure which regulates selfishness for the good of the system or organization as a whole.

The course of the theoretical debate upon the evolution of Multicellularity and individuality during the 20th century with respect to cooperation and selfishness is usefully summerised in two complimentary works on developmental biology: *The*

Evolution of Complexity by Bonner (1988) and the *Evolution of Individuality* by Buss (1987). Their theorizing has centered around conclusions drawn from the observation of slime-moulds. Slime moulds exist in both the unicellular and multicellular worlds at different points in their life-cycles and it seems reasonable to suppose that they can tell us something about how multicellularity may have evolved.

Buss tends to take a Weismannian point of view, stressing the evolutionary significance of within-individual competition between cell-lineages and variants. Buss when discussing ‘primitive’ multicellular organisms pays particular attention to the existence of somatic parasites in slime moulds. Cells gaining preferential germ line status through exploiting others. Buss presents a speculative hypothesis concerning the evolution of epigenetic systems. It is argued that somatic cell lineages in the act of relentlessly and selfishly pursuing their own replication may incidentally have enhanced the replication rate of other lineages. When such relationships also benefit the individual then there would (among animals without a sequestered germ line) be strong selective pressure in favour of their preservation.

Bonner, although not denying the existence and potentiality for within-individual conflict, takes a less extreme, more Kropotkian position, that sees individuality resulting from reciprocity and synergy between differing cell types. Unlike Buss, he thinks that the “the remarkable thing about the stalk cells” of slime moulds, “is that they become vacuolate and die; they are altruists and help the genetically related sister cells to pass on their genes by forming spores.”[341] Bonner clearly feels that kin-selection and group selection are not distinguishable in this case.

[341] Bonner, *The Evolution of Complexity*, New Jersey, Princeton Uni Press, 1988, page 163.

However, whether cells be altruists or egoists, both Buss and Bonner stress, that there is a potential for considerable conflict between the many and various components at the different organisational or developmental levels of a multicellular individual. But, these have been successfully resolved, in favour of the collective or individual, in a very great number of ways. Although it is not possible to examine in depth the debates surrounding evolution, mutualism and the development of multicellularity, it is certainly worth briefly reviewing the main points.

Mutual Aid and Increasing Size Equals Selective Advantage

Multicellularity, it would appear, has evolved independently among divergent life forms many times over. It is concluded that, increasing size confers many evolutionary advantages. Many "cells together can feed more effectively than separate, single cells". Slime moulds, by virtue of becoming larger can "secrete quantities of extracellular digestive enzymes sufficient to break down large particles of food that are beyond the capabilities of the single cells". Other suggested advantages of multicellularity are more effective dispersal mechanisms (through growing fruiting bodies etc), and the fact that larger organisms can escape predation and become more effective predators.[342] All of the above suggestions are classically Kropotkian and compatible with his suggestion that "the earliest aggregations of cellules" are "instances of association in the struggle".

Differentiated and Non-Differentiated Types of Multi-Cellularity

Multicellularity allows for cell specialisation. The evolution of cells for specific tasks enables organisms to acquire new abilities, undertake many tasks at the same time and occupy new niches or do so more effectively.

[342] Bonner, *The Evolution of Complexity,* New Jersey, Princeton Uni Press, 1988, pages 65 and 116.

Some slime moulds comprise of a single type or uniform cells. In others, cells differentiate into two or three types, including gravity resistant stalk-cells. Stalk-cells, unlike those that become spores, don't reproduce.

Similarly the types of protist cells from which animals developed are unable to move and divide at the same time. Although such limitations can be solved without multicellularity it has been found selectively advantageous to have cells that are responsible for motility (usually on the outside) and cells responsible for reproduction (safely inside).

The Evolution of Multicellularity

Multicellular organisms have achieved differentiation and specialisation in two main ways: The Mosaic and Regulative model of development. These are matters of degree rather than absolute differences because, all organisms are subject to some degree of mosaic/cytoplasmic/maternal control in early ontogeny.

In *Mosaic* development the fate of cell lineages is determined mainly by localised determinants in the fertilised egg."[343] The various cell-types are placed or grow in a particular or fixed area of the developing embryo. This has some advantages, such as "simplicity and perhaps the reduction of developmental errors. But, mosaic development is ill suited to recover from any kind of injury or disturbance."[344] In the *regulative* mode of development "the fate of cell lineages is determined mainly by cell-cell interactions."[345] In this model cell differentiation is brought about through the interaction of different cell lineages or variants, leading to cascades of secondary differentiations of morphology and function. Generally it may be stated that small animals with short life spans tend to have a strongly mosaic

[343] Jablonka and Lamb, page 295.
[344] Bonner, *The Evolution of Complexity*, page 181.
[345] Jablonka and Lamb, page 295.

development and a very low rate of cell turn-over whilst plants and vertebrates have a strongly regulative type of development with very high levels of cell turn-over throughout their longer lives.[346]

Competitive Individualism/Survivalism and the Growth of the Multicellular Individual

At all levels in multi-cellular organisms the integrity of the individual is threatened by selfishness at lower levels and must be held together by higher levels of co-operation. Selfish or mutant DNA must be silenced. The possibility of selfish (read high rate of replication) cytoplasmic organelles overtaking the cell must also be controlled. Parasitic cell lineages must be prevented from acting in their own rather than the whole organism or individual. Genomes have developed ways of silencing selfish DNA, the cell has found ways of regulating the reproduction rate of its organelles and cells keep each other in line by means of a variety of processes. These mechanisms are not perfect; mammalian cancer for example, is an only too common case in point.

The three main multicellular kingdoms, plants, fungi and animals have all solved the problem of restraining undesirable genetic and epi-genetic variants in very different ways.[347] In plants variants are always tested somatically, and if they fail to produce viable buds they will loose out in competition to other normal healthy ones. Unlike mammalian cancer cells, plant cells cannot move such that tumours (often seen as lumps on tree trunks) are simply left harmlessly behind. In fungi where many nuclei share a single cytoplasm, their division and reproductive status is strictly synchronised by a number of mechanisms (particularly the timing of cellularisation) crucial to reproduction such that harmful variants cannot come to dominate. It is

[346] Jablonka and Lamb, page 210.
[347] These are reviewed in Buss.

argued by Buss and Maynard Smith[348], both of whom who hold versions of the individualist-competitive-Weismannist perspective, that in some highly-differentiated, multicellular organisms and at least for all vertebrates, fierce competition between selfish somatic variants that forego somatic duties, and attempt to take on germ line status (the 'selfish cell' rather than the 'selfish gene') has led to the evolution of a variety of mechanisms in higher animals which ensure the integrity of the individual. These mechanisms include the development of individuals from a single totipotent cell, the maternal/cytoplasmic control of early development (especially mosaic development), separate or sequestered germ line and meiotic sex. The sequestration of the human germline on the 56th day in the development of the embryo until puberty is evidence of an adaptive evolutionary triumph of the individual over competition between different or variant cell lineages. This, however, is only a hypothesis and an equally plausible co –operative account can be constructed. The ability of cells to forego reproductive status by becoming a stalk or liver cell can be viewed as an act of mutualistic altruism by one sister-cell to another in the achievement of greater reproductive success:

"Rather than thinking in terms of competition, we prefer to think about the evolution of development in terms of co-operation between cell lineages that are genetically identical, even if epigenetically different. Changes that cause some cells to forgo reproduction and take on somatic functions are favoured if the behaviour of those cells confers additional reproductive advantages on sister cells, and therefore on the organism as a whole."[349]

Organic Codes, Social Metaphors and Epigenesis:

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[348] Maynard Smith, J., *Evolutionary Progress and Levels of Selection*. In *Evolutionary Progress*, (ed. Nitecki M), University of Chicaco Press, 1988. pages 219-30.

[349] Jablonka and Lamb, page 206.

Barbieri in an exciting new work *The Organic Codes*[350] explains epigenesis explicitly in terms of collective, community or group metaphors. Barbieri's modeling of epigenesis relies upon well understood mathematical concepts that have quite general applications in technologies such as electron microscopy, x ray imaging or any other processes involving the exact reconstruction of images or data from very incomplete information by means of programs linking memories containing information gained from past projections with information that will be gained from new projections that transfer and utilize information stored in memory space in real space.

Babieri has developed mathematical models of convergent increases of complexity in development as a: "special case of the general problem of reconstructing structures from projections, a problem which arises in fields as diverse as radioastronomy, elecron microscopy and computerized tomography." Indeed the problem of reconstruction from incomplete information arises when imaging, reproducing or transferring a "three-dimensional body onto a two dimensional surface, and this process is inevitable accompanied by a loss of information." There are "mathematical systems capable of constructing the original from "10% or less of the minimal information" or at least one order of magnitude less than the theoretical minimum". For example, a "series of pictures which are increasingly more accurate approximations of the original" are generated in the 'structure space' and the information gained from them stored in the memory space. In many pictures the "errors are totally random, but, invariably there are other points where this does not happen. In those points the illegal values keep reappearing each time." Such "points" and often called "vortices". "The new information of the vortices appear in the memory space but we use that information in the structure space." Barbieri claims to give us the "precise formulation to the problem of reconstructing structures *from incomplete information*.

[350] Barbieri, M., *The Organic Codes: An Introduction to Semantic Biology*, Cambridge University Press, 2003.

Reconstructing structures *from incomplete information* is equivalent to a *convergent increase of complexity*" and is in fact the "mathematical formulation of the problem of epigenesis" "A reconstruction from incomplete information requires memory and codes. The reconstruction memory is where new information appears. The reconstruction codes are the tools that transfer information from the memory to the structure. "convergent increase of complexity can be achieved if a reconstruction is performed with memories and codes. Which means that, epigenesis requires organic memories and organic codes." "The biological implications of the above model are straightforward. Embryonic development is also a reconstruction of structures from incomplete information, and so it must employ organic memories and organic codes."[351]

> "There cannot be a convergent increase of complexity without memory" "Real space and memory space must be autonomous worlds, because if they were equivalent they would convey the same information and no increase in complexity would be possible. But between two independent worlds there is no necessary link and no information can be transferred automatically from one to the other. The only bridge that can establish a link between such worlds is an ad hoc process i.e. a convention or a code. This amounts to a second universal principle: there cannot be a convergent increase in complexity without codes." "The existence of a real organic code is based on (an can be inferred form) the existence of organic molecular adaptors that perform two independent recognition processes. In the genetic code the adaptors are the transfer RNAs."[352]
>
> "Embryonic cells have two distinct organic memories the genetic memory of the genome and the epigenetic cell memory of determination." The genome and the "collective memory matrix of the body plan within which "information is deposited in a supracellular memory." "Cell memory is a key structure of embryonic development because it is essential to the convergent increase of complexity that is typical of development"[353]

The Phylotype and the Cambrian Explosion:

One puzzling aspect of embryological proceses is that they are not a not a continuous process of divergent complexification "from fertilized egg to adult"

[351]Barbieri, M., *The Organic Codes*, pages 4 and 69-70
[352]Barbieri, M., *The Organic Codes*, pages 90-93
[353] Barbieri, M., *The Organic Codes*, pages 206-14

“Before the phylotypic stage, the morphological difference between the embryos of a phylum are decreasing, whereas after that stage they are increasing…The pattern which is observed before the phylotypic stage cannot be explained by the same evolutionary mechanism. Before the Cambrian explosion “animals were necessarily small and relatively simple, because there is a limit to the number of character that can be directly controlled by the genes.” During the Cambrian explosion there was a shift to an embryonic development in which “The supracellular information of the body plan allowed the addition of new developmental stages, and a longer development could produce a more complex and larger animal” “This did not require many genetic innovations, because the body plans were *already existing* and provided ample deposits of potential information for the spatial pattern of organs and apparatuses.”

> “The Cambrian explosion was the transition from a primitive type of development that was totally controlled by genes to a discontinuous type of embryonic development that could also use, from a certain point onwards, the supracellular information of the body plan. The general properties of this collective memory not only correspond to real biological characters, but can also be simulated by a mathematical model”[354]

Codes and Conventions:

> “The highway code is a liaison between illustrated signals and driving behaviours.” “Codes, Rules and laws have been thought of as exclusively cultural phenomena that are fundamentally different from the laws of physics and chemistry.” (96 “Words of a [human] language may seem arbitrary if considered one by one, but together they form an integrated system and are linked by community rules. Codes and meanings are similarly subject to collective, not individual constraints.”
>
> “Codes have 3 fundamental characteristics:
>
> (1) The connect two independent worlds
>
> (2) Add meaning to information
>
> (3) Are community rules”

[354] Barbieri, M., *The Organic Codes*, pages 211-14

> “There is a qualitative difference between *informatic processes*, where only energy and information are involved, and semantic processes, where rules appear which add meaning to information.” “Codes, Rules and laws have been thought of as exclusively cultural phenomena that are fundamentally different from the laws of physics and chemistry.” “The genetic code proves that in nature too there exists a conventions which builds bridges between informatic and semantic process—DNA transcription and RNA translation.” “Transfer RNA is an adaptor molecule that performs two independent recognition steps, one in the nucleotide world the other in the amino acids”[355]

Barbieri’s theory of epigenesis explicitly uses collective and community metaphors to explain the logical inference of the “real existence” of shared memories, understanding and meaning in genetic and other microbiological processes. He concludes that “biologists have only looked for individual features in genes and proteins, not for group properties” which are “elusive”.[356]

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[355] Barbieri, M., *The Organic Codes*, pages 94-8
[356] Barbieri, M., *The Organic Codes*, page 237

Chapter 4

Evolution and Environment: The Weismann-Kropotkin Debate

Kropotkin's famous study *Mutual Aid* was a critique of Huxley's social Darwinism. In his later work upon biological theory, (published in book form for the first time in 1995) Kropotkin attacked Weismann's neo-Darwinism. This article examines the historical debate between Kropotkin and Weismann in relation to contemporary scientific discoveries, debates and perspectives in environmental genetics.

Weismann's Non-Transmission Theory:

August Weismann was an influential late 19th century biologist. He is the most famous exponent of the theory of the non-transmission of environmentally induced or adaptive modifications. He believed that, very early in the development of both plants and animals the germ line or reproductive cells were set-aside and remained unchanged. The somatic or body cells constructed and maintained the organism throughout its life, but played no role in reproductive processes. According to Weismann no envrionmentally determined or adaptive changes occurring during the lifetime of an individual are inherited unless, the environment effects the germ-line cells in a similar way. Although this does occur (Weismann termed it parallel induction), as Weismann's own (though unoriginal) experiments upon the effects of temperature on butterflies showed, he didn't consider it a significant exception to his theory.

Kropotkin opposed Weismann and defended the alternative theory of the *direct action of environment* and the *inheritance of acquired characters*. Unlike natural selection, direct transmission is non-conflictual. The struggle for existence involves adaptation to the environment; the ability to find new food sources or grow thicker fur:

> "there is no need of an acute struggle between the individuals of the species to preserve the effects of variation. The acting cause will itself accumulate them, and increase them in the subsequent generations. The hypothesis which saw in the struggle for life the cause of accumulated variation is no longer necessary, once we have in the direct action of environment a *real* cause producing the same effects."[357]

There were numerous other aspects Weismann's ideas that Kropotkin opposed. In some of early articles Weismann attempted to reconcile the randomness of natural selection with some purpose or master plan in the universe. Kropotkin claims that, Weismann's description of the germ cells as 'immortal matter' was an attempt to "combine the pre-Darwinian conception of innate pre-determined variations with the Darwinian principle of natural selection"[358]. Kropotkin thought the introduction of teleology and metaphysics into biology was a growing trend and was particularly disgusted by it:

> "Weismann and his disciples wish for an evolution predetermined (by the Mechanisms of the Universe) by means of a substance possessed of an "immortal" soul—this Hegelian creation of Weismann, his germ plasm theory…has plunged biology into a situation where, for 30 years, hundreds of pages of dialectical biology have been written in place of the experimental research of previous times."[359]

Weismann regarded the cell's nucleus as the controlling locus of reproduction and control. Kropotkin believed that nucleo-centrism was insupportable because of abundant evidence of cytoplasmic-nucleus interaction in early embryological development. There was also the fact of cytoplasmic inheritance:

> "We [have] learned from the best embryologists that the living substance which is the bearer of inheritance is *not* localised in the nucleus of the germ-cells; and

[357] Kropotkin, *Evolution and Environment*, Quebec, Black Rose Books, 1995, page 138.
[358] *The Direct Action Of Environment And Evolution*, The Nineteenth Century And After, Vol 85 (1919), page 78.
[359] Todes, D., *Darwin Without Malthus*, page 141

that an intercourse of substances between the nucleus and the cell-plasm must be taken as proved."[360]

Although some cytoplasmic role in development and inheritance has never been denied, it has been largely ignored since the end of World War II[361], and its importance, perhaps significantly underestimated:

"The phenomenolgy of embryogenisis has been greatly enriched by molecular genetics, but these studies simply do not address the problem of how the genes become expressed in their particular spatial configurations during development. Spatial organisation begins with physiochemical processes that set up spatial patterns of cytoplasmic states. The latter, in turn, trigger the differential expression of genes."[362]

"Our concept of heredity includes—besides nuclear genes, maternal and cytoplasmic effects which provide the material link between development and evolution. The egg cytoplasm is both the carrier of heredity independently of the nuclear genes and the necessary interface between nuclear genes and the environment in the co-ordination of developmental and evolutionary processes."[363]

"Cumulative cytoplasmic or maternal influences could lead to an increase in the phenocopy response in successive generations…Since the egg cytoplasm and cortical organization are conditioned by both maternal genes and environment, it seems reasonable to conclude that the special environments experienced by the mother in successive generations may be passed on cumulatively in the egg…Cumulative cytoplasmic effects may be responsible for the canalization of novel phenotypic responses to environmental challenge."[364]

Kropotkin asks how the Germ Cells are able to live a "sleeping beauty existence"[365] in an "inner sanctuary"[366] when, they are fed by and live in "close intercourse" with the body cells. An obvious case "in point", he correctly asserts, is

[360] Ibid, page 76. See also Recent Science, Dec. 1892 pages 1011-14 where he discusses in detail the ideas of Geedes, Verworn, Hertwig, Van Beneden, etc., upon the issue of cytoplasmic inheritance.

[361] The reasons for the lack of interest in cytoplasmic inheritance are complex involving political and historical factors in addition to scientific ones. See Sapp. J., *Beyond the Gene: Cytoplasmic Inheritance and the Struggle for Autority in Genetics*, Oxford University Press, 1987

[362] Ho, *On Not Holding Nature Still: Evolution by Process, Not by Consequence*, in Ho and Fox (eds) *Evolutionary Processes and Metaphors*, page 127.

[363] Ho, *Environment and Heredity in development and Evolution*, in *Beyond Neo Darwinism*, page 268

[364] Ibid, page 274

[365] Kropotkin, *Evolution and Environment*, Quebec, Black Rose Books, 1995, page 194.

[366] Ibid, page 192.

the "many well-known cases of infection of the germ-cells by bacteria developed within the body-cells."[367] Infection in bacteriology need not imply pathological effects, indeed, it can welcome the arrival of a potentially useful symbiotic partner. Cytoplasmic and viral infections are acquired characters that may be passed directly from the mother to her children, as seen in the AIDS epidemic. Although "across species…insertional events…may result in pathology" they can also "possibly be a means of bringing a new functional protein de novo into an organism"[368]

Kropotkin disliked the explicit uni-directionality, centralisation and hierarchy of Weismann's thesis, according to which the nucleus is regarded as being in control of the cell and its reproductive processes. Kropotkin described Weismann as "The Karl Marx of biology"[369].

> "There is a strong hierarchy among Weismann's determinants. There are determinants of each arm which govern the development of the arm in the embryo, and there are subordinate determinants for marshalling the development of each finger, each nail, each muscle, etc., of the arm and the hand. The development of the embryo thus reminds one of the mobilisation of an army, of which the determinants are the officers and sub-officers organising its different parts"[370]

Kropotkin considered all theories of inheritance purely hypothetical. Neither Darwin's 'pangenesis' theory (where representative spores of each cell or type of cell collect to form the germ plasm[371]) nor Weismann's notion of immortal centralised determinants, were both purely speculative. Weismann in Kropotkin's eyes had incorporated social, cultural and spiritual prejudices into his theories. Weismann's

[367] Ibid, page 241.

[368] Pollard J., *New Genetic Mechanisms and Their Implication for the Formation of New Species*, in Ho and Fox (eds) *Evolutionary Processes and Metaphors*, page 75.

[369] Daniel P. Todes, *Darwin Without Malthus: The Struggle for Existence in Russian Evolutionary Thought*: New York, Oxford University Press 1989, page 203.

[370] Kropotkin, *Evolution and Environment*, Quebec, Black Rose Books, 1995, pages 190-1.

[371] As discussed above, a modern version of the pangenesis theory has been suggested by Steele. The hypothesis states that somatic variants of antibody V genes may come to dominate in certain tissues and can be transferred to germ cells by endogenous viral vectors. This is not impossible but has hardly been proved to be true.

linear, nucleo-centrist, non-reversible, uni-directional and static notion of inheritance dominated genetics until fairly recently.

The 'new genetics' in the 1970's revealed that genomes are de-localised with no hierarchy or one to one linkage between a particular gene and a corresponding character. Characters evolve from the expression of many different and widely dispersed genes. Genetic expression involves a wide variety of elaborate feedback, editing (by RNA), splicing and recombination processes meaning that, the transcription, translation and expression of the genes is not strictly determined by the genome, but is part of a process of 'becoming' involving a series of causal loops between RNA, DNA, the individual cell and its environment. Genes can be turned on or off and sequences can be re-arranged in an almost indefinite variety of re-combinations:

> "nearly all genes can be considered as members of different gene families and probably in higher organisms no gene exists in a single copy…members of gene families engage in genetic exchanges by means of transposition, unequal crossing over and gene conversion with and without RNA intermediates"[372]

The expression of DNA is now conceived in terms of immensely complicated multi-layered, decentralised, non-hierarchical "epigenetic super-networks"[373] in which, information is passed backwards and forward in every direction throughout an interrelated, interactive and highly dynamic developmental web. Kropotkin's criticisms of Weismann's centralised hierarchicalism have been validated by contemporary genetics:

> "DNA, by itself, can specify nothing at all, as DNA depends, for its replication, on the entire cell. What the findings of the new genetics also show is that the gene itself had no well defined continuity or boundaries, the expression of each gene being ultimately dependent on, and entangled with, every other gene in the

[372]Pollard J., *New Genetic Mechanisms and Their Implication for the Formation of New Species,* pages 66-7.
[373] Ho, *Gentetic Engineering,* page 49.

> genome. There is certainly no one-way information flow proceeding from DNA to RNA to protein and the rest of the organism, as projected by the centralist dogma. Instead, gene expression is subject to instructions, modifications and adjustments, according to the environmental, physiological and cellular contexts. Moreover, the base sequence of DNA in genes and genomes is subject to small and large changes in the course of normal development and as the result of environmental perturbations...By far the most significant picture to emerge from the violations of the centralist dogma of molecular biology is that of the dynamism and flexibility of the genome in both its organisation and function. This is in striking contrast to the relatively static and mechanical conception that previously held sway."[374]

This is in stark contrast to the naïve developmental metaphors (preformist-like information-replication matrices) underpinning both Weismann's and (his modern equivalent) Dawkin's conceptions:

> "Like *embryo*, *child*, *adolescent*, abstract nouns like, *development*, *construction*, *flight*, verbs like to become, to *grow*, even to *die* are very difficult to handle mentally for most people."[375]
>
> "The initial difficulty is that people really do like prefomation as the explanation of pattern: we like to claim that pattern happened because what was there beforehand cryptically laid down the pre-pattern. In classical embryology this was the homunculus in the sperm, or the eggs as Russian dolls with all their descendants. Too often in modern biology, even embryology, it is the 'DNA blueprint' whose replicated (pre-formed) pattern is supposed to form the basis of the embryo's structure, then to complicate this into the adult. No explanation of increasing complexity is required because it doesn't increase."[376]
>
> "If there's a little man in the sperm it only has to get bigger; if there's a DNA blueprint it just has to be actualised in flesh. 'Conservation-of-information' seems to be our default."
>
> "We even speak of the DNA message 'passing across the generations' when there is no receiver; indeed, the implied function of the massage is to build the receiver. The information-metaphor falls apart in all kinds of ways; for example, there is not enough information in a mammal's genome to specify the neural connections of quite a modest mammal never mind the human brain"
>
> It makes a good story; it sounds as if it works. So did the little man in the spermatozoon, so does DNA-made-flesh in the modern equivalent. We need new

[374] Ho, *Gentetic Engineering*, page 104.
[375] Cohen J., *Becoming Maureen—A Story of Development*, page 49
[376] Cohen J., *How Does Complexity Develop?*, page 10

> metaphors for development, and there have been many attempts to invent them, to progress, from the conservation-of-complexity models into the real world, where complexity is lost or gained all over the place. I am intrigued by a very obvious real-world example, the way flames re-invent the morphology in each 'generation'"[377]
>
> "But most papers in the field, many of the best books and successful laboratories, promote and use genes-as-information and genes-mapping-to-single-characters metaphors. Those are the stories we find in the media and science fiction stories have run with this idea too; because it doesn't require much from the reader. Only the development of a print from an exposed film. The picture is implicit in the system from the beginning."[378]

Geneticists are not only interested in the DNA but also its expression. Genes, like Shakespeare's plays can be expressed in many ways. Genes can be silenced (not expressed), amplified (repeated) and transposed (copied and/or moved from one place to another). There can be considerable difference of expression between genetically nearly identical cells. In epigenetic states the difference is with the topology of expression. Some differential or epigenetic states can be inherited, although, the marks which determine these varying expressions are generally erased in mammals early in reproductive processes. But sometimes they are not. Exploration of the phenomena of maternal inheritance or the persistence of 'stubborn marks' reveals many interesting phenomena. For example, it has been known for some time that some of these "incomplete erasures" are expressed by an animal's grandchildren, and help explain such well documented phenomena as the "fact that the grandchildren of pregnant women malnourished during the Dutch famine, 55 years ago, were born underweight". Another recent example of this phenomenon, grandmaternal epigentic inheritance, involves the silencing of an allele at the agouti locus in mice; an epigenetic modification that was incompletely erased and passed through the female germ line. The silencing of this gene, although inducing

[377] Cohen J., *Becoming Maureen—A Story of Development*, pages 50-2
[378] Cohen J., *Becoming Maureen—A Story of Development*, page 55

pathological effects also produced an astounding diversity of fur colours. "The mark did not change the DNA sequence of the coat colour gene, just the degree to which it is switched on or off." These non-genetic or epigenetic marks "acquired during a mother's life time can be inherited."[379]

The Theory of Natural Selection and Environmentally Determined or Induced Variation/Adaptation:

Kropotkin rejected Weismann's notion of the sufficiency of Natural Selection; an idea that was orthodoxy for most of the 20th century.

Darwin's thoughts concerning domestication supported the idea that, environmental change induced rapid variation. But, according to the theory of natural selection random and "indiscriminate" micro-variations that could be "useful, harmful or indifferent"[380] are continually generated by processes that are "purely accidental or indeterminate, i.e., guided by no special cause one way more than the other"[381]. Natural selection favours the survival of individuals "under given circumstances", which by pure chance possess that cluster of useful randomly generated variations, best fitted to a given environment. Conversely, natural selection leads to the "extermination" of those individuals, who by pure chance, are without them.[382] The environment is an agent of *selection* not *variation*. Organisms are unresponsive to the environment. Selective advantage is pure luck. Adaption is an incidental consequence of environmental sorting of random variations that are not influenced in a direct causal way by that environment.

[379] Morgan, Sutherland, Martin and Whitelaw, *Epigenetic Inheritance at the Agouti Locus in the Mouse, Nature Genetics*, Vol 23 (#3), November 1999, pages 314-18 and Smith, D., *Bowie's Face Oddity Solved*, Sydney Morning Herald, November 11, 1999.

[380] Kropotkin, *Evolution and Environment*, Quebec, Black Rose Books, 1995, page 125.

[381] Ibid, page 139.

[382] Kropotkin, *Evolution and Environment*, Quebec, Black Rose Books, 1995, page 125.

Darwin, continually modified his views in the light of new evidence. He came to question the sufficiency of the "bean-bag", "card-shuffling" or "lottery" conception of variation. The later Darwin embraced the possibility of environmentally induced changes, variations and adaptations and their inheritance: "There can be no doubt that species may become greatly modified through the direct action of environment. I have some excuse for not having formerly insisted more strongly on this head in my *Origin of Species*, as most of the best facts have been observed since its publication"[383]

Kropotkin was a faithful student of Darwin. He saw a role for natural selection and heritable environmentally induced modifications. Kropotkin considered himself a Darwinian, though not a social or neo-Darwinist:

> "It is evident that...Darwin was perplexed how to determine the part which belonged to Natural Selection and that which belonged to the Direct Action of the surroundings—the 'mistress' and the 'handmaid.' He apparently realised sometimes that the handmaid who produced the variation could submit to Natural Selection variations so useful that little choice was left for the approval of 'the mistress.'"[384]

Kropotkin thought that, in order to account for rapid morphological, reproductive or behavioural changes, there must be some positive adaptive response or an environmentally determined effect (which need not be adaptive) in the presence of a constant external influence, in additional to random micro-mutations to give direction to evolution and create rapid enough rate of change in an organism to gain selective advantage. Micro mutations without some additional cause would simply be ironed out by the law of averages and be far too slow to allow organisms to adapt

[383] Darwin, Life and Letters Vol. 3 page 232, quoted by Kropotkin in *The Direct Action Of Environment And Evolution*, page 70.

[384] Kropotkin, *Evolution and Environment*, Quebec, Black Rose Books, 1995, page 128.

to changing environmental conditions. Kropotkin thought that, adaptations and new species appeared too quickly for gradualism to be tenable.

Kropotkin did not deny the existence of random or accidental mutation, indeed, without some degree of randomly induced novelty evolution would be impossible.

All of Kropotkin's objections to the self-sufficiency of natural selection were standard anti-Darwinian arguments around 1910 and are compatible with all major schools of the time (neo-Lamarkism, orthogenesis, mutationism etc.)[385]

The idea that organisms are directly adaptive or exhibit induced genetic responses to their environment was dismissed in developmental, evolutionary and theoretical biology for most the 20th century. This was due to bias against botany, and perhaps, a misinterpretation of the experimental evidence concerning non-random mutation in bacteria.

Recent evidence suggests there are a variety of processes that allowing for the inheritance of acquired characters. Bowler, on the basis of recent work by Steele and a revival of interest in Goldschmidt's ideas (who built upon developmental concepts of the orthogenic school) noted, in 1983 that: "biologists are once again debating the validity of experimental evidence for the inheritance of acquired characters. Some of the old dogmas in genetics are beginning to break down, and a new, more flexible approach is emerging—one that may include a place for effects that would once have been called Lamarkian". Although Bowler suggests that his own historical study cannot affect the "purely scientific questions involved" he believes that, this may well be achieved through a new synthesis that transcends both the Darwinian and Lamarkian traditions.[386] Since Bowler wrote these words considerable evidence has surfaced rendering this new synthesis inevitable. Steele has raised the possibility that

[385] See Bowler's *Eclipse*.
[386] Bowler, P., *The Eclipse of Darwin*, page 6

somatically selected hyper-mutated antibody V region genes (in vertebrates) may occasionally be transferred from lymphocyte regions to the germ cells. This “could be effected via the agency of enzyme reverse transcriptase (copying somatic RNA into DNA) plus the ubiquitous, naturally occurring, endogenous retroviruses (produced by lymphocytes) acting as ‘gene shuttles’ ferrying mutated V-region gene sequences into germ cells.”[387] Steele presents some compelling theoretical arguments suggesting that such transfers occasionally occur. But, as in the 19th and early 20th centuries, it is hard to prove: Experiments “requiring rigorous control” and involving the keeping large populations of mice over decades, are inherently problematic. Various forms of contamination and bad luck can all undermine the validity of data because during long experiments there is a greater risk of such events occurring. Steele admits that, there is little “direct evidence” but, plenty of “indirect evidence” for his hypothesis.[388] It must be concluded that, ‘hard’ evidence for somatically acquired mutations effecting changes in germline base DNA is scanty.[389]

But, there are other processes, collectively known as epigenetic inheritance systems, effecting the inheritance of acquired characters by means other than changes in the base DNA in the germline cells.[390]

The Inheritance of Acquired Characters in Plants:

Kropotkin believed that experimental evidence showed a close relationship between environment and plant morphology. A recent article analysing similar data

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[387] Steele, T., Lindley, R., & Blanden, R. *Lamark’s Signature: How retrogenes are changing Darwin’s natural selection paradigm*, Sydney, Allen & Unwin 1988 page 166

[388] Steele, T., Lindley, R., & Blanden, R. *Lamark’s Signature*, page 206

[389] Kropotkin thought very highly of the universally acknowledged 19th century pioneer of moc immunology, Elie Metchnikoff. Kropotkin’s article upon Metchnikoff is noteworthy as, it contains an interes debate upon the “extension of the leading principles of struggle for life to the microscopic constituents of animal body”

Recent Science, The Nineteenth Century August 1892 pages 237-242

[390] The literature on this subject matter is usefully reviewed by Jablonka and Lamb’s 1995 study epigentic inheritance.

confirm many of his conclusions.[391] Plant growth and structure is different to animals whose development and reproduction unfolds as a unified program. Plants are "open organisations" that are "modular" or regionally autonomous. Different "pods, or two ears of the same plant"[392] may be subject to different environmental conditions and exhibit a variety of morphologies.

Kropotkin payed particular attention to alpinism. He notes that, lowland species grown under alpine conditions appear to adapt and resemble natural alpine specimens. Bowler in his assessment of Kropotkin states that, he "exposed the weakness" of his own arguments when he "conceded that alpine species grown at a lower altitudes soon loose their particular characteristics".[393] Bowler is partially mistaken. Kropotkin thought rather, that, the evolution of phenotypic plasticity was an important evolutionary development in its own right. "Unlike Darwin and his followers who had ignored what was to be Johannsen's crucial distinction between phenotype and genotype"[394], Kroptotkin was familiar with Johannsen's major work reading it shortly after it was first published. Kropotkin praised Johannsen's "latest writings [where he had] come to the conclusion that without inherited variations 'selection would have no influence'".[395] Alpinism is still explained in terms first developed by Johanssen. Adaption to the environment doesn't require genetic change only genetic regulation of expression. Phenotypic variation in plants is not however, superficial. It can effect "ecological, morphological, anatomical, karyological,

[391] Schmid, B *Phenotypic Variation in Plants*, Evolutionary Trends in Plants, Vol 6 (1) 1992, pages 45-60.
[392] Kropotkin, *Evolution and Environment*, Quebec, Black Rose Books, 1995, page 219.
[393] Bowler, P., *The Eclipse of Darwin*, page 87
[394] Bowler, P., *The Eclipse of Darwin*, page 25
[395] *The Direct Action Of Environment And Evolution*, The Nineteenth Century And After, Vol. 85 (1919) page 87

physiological, biochemical, and molecular characters". It is often difficult to make any strict separation between genotype and phenotype.[396]

Kropotkin thought that, the plasticity of plants in response to environmental change was a "protective adaption".[397] Natural selection eliminating those species without "enough plasticity"[398], to respond to environmental challenges with a sufficiently broad environmentally activated/directed phenotypic repertoire. Modern research suggests that, natural selection has indeed acted on plants strongly in favour of "general purpose genotypes which adjust by phenotypic plasticity to different environmental conditions"[399], as well as "allowing for the evolution of highly specific patterns of plasticity"[400]. The evolution genetically regulated or programmed developmental responses, Kropotkin thought, was an important theoretical concept that had substantial grounding in experimental biology.

Kropotkin understood how the phenotypic plasticity of plants made it extremely difficult to differentiate what is "racial inheritance" from the somatic responses of the "individual" which undergo "fluctuating modification due to the always fluctuating exterior conditions".[401]

Kropotkin was interested in regional and topographical specificity and variability of plant life (plants are often narrowly restricted by soil conditions or type). He observed how plants seem particularly sensitive to local environmental conditions, such that, an oak is "capable of reproducing, not only some sort of oak, but that special sort of oak, which has been evolved since the Post-Glacial period in a

[396]*Phenotypic Variation in Plants*, page 48.
[397] Kropotkin, *Evolution and Environment*, Quebec, Black Rose Books, 1995, page 158.
[398] Ibid, page 156.
[399] *Phenotypic Variation in Plants*, page 51.
[400] Ibid, page 53.
[401] Kropotkin, *Evolution and Environment*, Quebec, Black Rose Books, 1995, page 219.

given geographical region, in certain definite topographical conditions."[402] Kropotkin also makes note of the considerable diversity within staple food crops[403] (and the weeds encouraged by cultivating them[404]) grown over a very wide geographic area, such as wheat and flax.

Kropotkin also considered vegetative reproduction or artificial propagation by means of cuttings. These have long been known to transmit acquired variations. Kropotkin suggests that, the acquired adaptations that characterise alpine plants enabling asexual propagation by buds (necessary because of short growing season), may have led to the "immense number of perennial" species which colonised the land in northern hemisphere in the post-glaciation period[405], and which still predominate in the northern part of this region.[406] There are also the thousands of garden and agricultural varieties of flowers, fruit and vegetables that have artificially evolved through grafting or bud propagation.[407]

It is now known that phenotypic (or epigenetic) variation, within asexually reproducing plants or in cuttings, is broader than from plants produced from seed.[408] Bud variation, as Kropotkin suggests, may well have had a role to play in the evolution of new species during disruptive events in the recent history of the life on Earth.

Kropotkin notes that the idea that these variations "could be transmitted by seed" had previously been "doubted"[409]. Accordingly, Kropotkin examines experiments where plants are grown in enriched, impoverished, toxic or foreign

[402] Kropotkin, *Evolution and Environment*, Quebec, Black Rose Books, 1995, page 193.
[403] Ibid, pages 217-20.
[404] Ibid, pages 215-17
[405] Ibid, page 212
[406] *The Direct Action Of Environment And Evolution,* The Nineteenth Century And After Vol 85 (1919) page 81.
[407] Kropotkin, *Evolution and Environment*, Quebec, Black Rose Books, 1995, page 209.
[408] *Phenotypic Variation in Plants* pages 51-2.
[409] Kropotkin, *Evolution and Environment*, Quebec, Black Rose Books, 1995, page 205.

environments and appeared to acquire specific modifications/adaptations that were transmittable by seed. The more generations that plants were exposed to a novel environment, a correspondingly larger number of generations in the ancestral environment were required to loose them.

These 'lingering' or 'enduring' modifications are common in plants.[410] In plants as well as some organisms:

"germ cells are somatically derived, there is no clear distinction between soma and germ line. Throughout development there are cells that are multipotent, capable of giving rise to both somatic and germ-line cells"[411]

Although, not all somatic cells are able to become germ cells, epi-mutations acquired during development are, in varying degrees heritable. "Nutrition-modifications"[412], are well documented in plants. Arid, high-altitude adapted wheat, kept in a seed bank, after a number of 'grow outs' necessary to preserve the stock, will, in a fertilised, low-altitude environment rapidly loose those characteristics for which they were preserved. Increased nutrition, along with other kinds of "shocks", such as temperature, appear to effect "a specific labile fraction or subset of the genome", most notably "highly repeated sequences and transposable elements".[413]

Research upon phenotypic variation has revealed that, variation is not indefinitely cumulative, as Kropotkin hoped. Indeed, Johannsen's work on pure lines suggested this, in Kropotkin's own time. Without true genetic change after about five generations in a constant environment, plasticity reaches its limit and levels-off:

[410] These are reviewed in *Phenotypic Variation in Plants* page 51 and *Epigenetic Inheritance and Evolution*, pages 138-40.

[411] *Epigenetic Inheritance and Evolution*, page 43.

[412] Kropotkin, *Recent Science*, Sept. 1901, page 249.

[413] Cullis, C. *Control of Variation in Higher Plants*, in Ho *Evolutionary Processes and Metaphors*, pages 57-9.

"perhaps because plasticity itself had become genetically fixed by selection."[414]. Also, in the majority of plants certain structures of particular importance to reproduction, such as flower morphology and seed-size are noticeably non-plastic.[415] Kropotkin notes that, Darwin had observed these "continuous or fluctuating" modifications and and concluded that, they had "no value for the appearance of new species". Evolutionary pre-adaptive variety operating within particular limits may not "offer sufficient differences form the normal type to be of value for Natural Selection."[416] Kropotkin, although realising that the apparently pre-adaptive limits to environmentally induced or adaptive plasticity was a powerful argument against his position, nonetheless believed that, inherited environmentally induced or directed phenotypic differences/adoptions could provide enough variation or novelty upon which natural selection might act to originate new species.

Although not all differential or adaptive states are heritable, the existence of epi-genetic inheritance systems, in which epi-genetic information can be stably inherited without changes in base DNA sequences means that, it is likely that it has some role in evolution, especially in persistent novel environments where unanticipated phenotypes may be created and fixed. Some contemporary biological thinkers building upon ideas first elaborated by Waddington in the 1940s believe that:

> "Since the evolutionary process obviously does produce novelties, a view such as ours, that emphasizes the importance of directed variation, which are seemingly part of a pre-existing repertoire of responses, appears to paradoxical. In order to see why there is no paradox, it is essential to realise that 'directed' does not mean that induced variants are uniform', and it also does not mean that they are 'predictable' or 'adaptive'. If heritable variants are influenced and even

[414] *Phenotypic Variation in Plants*, page 52.
[415] Ibid, page 54.
[416] *The Direct Action Of Environment And Evolution*, The Nineteenth Century And After, Vol 85 (1919),page 82.

> controlled by environmental cues, it does not mean that all individuals in the population have identical epi-alleles...More important for understanding why there is no paradox in the evolution of novelties through directed changes, is the realization that new conditions may alter gene expression in unanticipated ways. The particular combination of active and repressed loci that is induced at a particular stage of development may be novel. The number of combinations of regulatory genetic networks is astronomical, and although only a small subset of these will be stable, it is difficult to believe that all stable networks have been realised in the ecological history of the population. The 'reaction range' of the individual—the range of its possible responses to environmental challenges—can be defined only a posteriori, because the environmental conditions may have unique aspects. A population exposed to a new environmental challenge will show a range of novel responses, and the variability is the material on which selection can operate...When the environment changes drastically and induces new phenotypes, evolution through genetic assimilation is possible. The store of previously 'neutral' variation becomes visible to natural selection and new combinations of genes can become fixed. For example, variations in the number of repeated sequences can assume selective importance in the new environment if they affect the ease with which the phenotype is induced. Even without changes in DNA composition, induced heritable epigenetic variations provide a way out of stasis, especially in groups without a segregated germs line. They provide an additional source of variation on which natural selection can act."[417]

When stressed plants "have a genetically controlled variation generating system". This variation is a source from which "better adapted lines" could be selected by natural selection. "In the absence of any 'shocks' the variation system is not active, or active at a very low level, and it is the exposure of the organism to the shock which causes the variation."[418] Plants, in times of environmental challenge, can be expected to exhibit a number of pre-determined responses as well as novel effects. This is because stress, whether environmental or from genetic attack, leads to the activation of specific and particularly volatile areas of the genome. This can have the effect of producing novel genomic re-organisations either because of the novel aspects of the inducing environment or more generally and less deterministically,

[417] *Epigenetic Inheritance and Evolution*, pages 281-4 passim.
[418] Cullis, C., *Control of Variation in Higher Plants*, page 60.

because of the destabilisation of the genome, leading to new re-combinations more random in their nature.

Adaption of Bacteria to the Environment:

Kropotkin believed that bacteria adapted to “new conditions of life” through their populations “undergoing inherited variation of structure.” He did not pursue this subject because of the difficulties of interpreting the data. In his day it could not be proved that, these apparent adaptions were not solely due to the natural selection of those members of the experimental population already possessing “some features rendering them better suited to their new surroundings”, or that the population was in the first place a “mixed” one; natural selection simply favouring one type or species of organism over another.[419]

Bacteria, have no nucleus and their genomes are extremely plastic. Bacteria have an array of processes transfering useful genes to each other. Bacteria reproduce by division so acquired genes are directly heritable.

Mechanisms for the horizontal transfer of genetic material among bacteria include, transformation, transduction and conjugation.

Transformation--DNA is directly taken up from the environment. DNA is absorbed into organic substrates particularly sand and clay and can remain intact for many hours and even days.

“It is of interest that DNA is not only released into the environment by the death of cells, but is actively excreted by living cells during growth. Some species export DNA wrapped in membrane derived vesicles. The DNA in culture slime can be more than 40% of the dry weight. Thus, the environment is extremely rich in DNA”[420]

[419] Kropotkin, *Evolution and Environment*, Quebec, Black Rose Books, 1995, page 225.
[420] Ho, *Gentetic Engineering,* page 155.

Transduction--mobile genetic elements, such as viruses and transposons insert their DNA into the Bacteria's chromosome.

Conjugation--bacteria use a tube-like structure (pilus) to transmit DNA. It used to be thought that this was limited by various incompatibility groups:

> "Recent studies indicate that conjugation has an extraordinarily wide host range, involving diverse, complex mechanisms that are not yet well understood. The promiscuous plasmids overcome species barriers, effecting horizontal gene transfer between phylogenetically unrelated species. In addition conjugative transposons (mobile genetic elements) have been discovered, which mediate their own transfer to recipient cells during conjugation and insert into themselves into the recipient chromosome. A special class of such conjugative transposons are integrons, which support the site specific integration of antibiotic resistant genetic cassettes. They can facilitate recombination between different cassettes to form exotic gene-fusions that code for multi-functional proteins. During conjugation, genetic material goes not only from donor to recipient, but also in reverse. Such retro-transfers of genetic material have only recently been discovered."[421]

Until the 1940's, it was generally assumed that bacteria were able to adapt themselves readily to environmental change. Following a series of experiments undertaken around this time appeared to support the opposite view. In the light of new experimental evidence undertaken during the 1980's the prevailing orthodoxy that bacterial mutability results from random non-directed processes has been challenged. Bacteria placed upon artificial or novel non-lethal inedible mediums cease dividing. Whilst starving bacteria appear to generate specific mutations enabling them to feed and begin dividing again. Adaption is implied because useful mutations appear at levels many orders of magnitude higher than would be expected *solely* from random, non-directed or indeterminate processes. The controversy

[421] Ho, *Gentetic Engineering,* page 157-8.

surrounding the interpretation and validity of these experiments has been intense, highly technical and the truth has yet to be scientifically established.[422]

When responding to a genetic parasites, physiological damage or environmental stress, novel mutations within genomes frequently occur. This is because genomic detection error and correction systems often go wrong or the environment or genetic parasite are novel. Mutations generated by these genomic processes are not straightforwardly accidental. They arise as a combination of many now well-recognised processes of genomic reorganisation and self-repair that are directed by the genome itself, but which may also destabilise the genome and have unpredictable, sometimes have far-reaching evolutionary consequences:

> "Analysis of chromosome organisation has revealed promiscuous behaviour of movable genetic elements, dynamics of genetic interchange, within gene families, gene amplification, silencing, gene conversion and interspecies gene transfer…[These are] not merely a passive quantitative or accumulative phenomenon, amplification deletion, divergence and translocations which reorganise repetitive gene families may be a major genetic mechanism of isolation between species."[423]

Adaption in Motile Organisms from Bacteria to Mammals:

Bacteria, many protists, plants, fungi and some animals do not have a segregated germ line or germ line segregation occurs very late in development allowing direct inheritance somatically acquired variation. However, in most insects and 'higher' animals the germ-line segregates early in embryological development and somatic variation in body cells is not heritable. However, "for more than a third of ...phyla,

[422] The experiments on directed mutation in bacteria and yeast are usefully reviewed in the following articles, neither of which seem to come to very definate conclusions. Lenski, R., and Mittler, J. *The Directed Mutation Controversy and Neo-Darwinism*, Science Vol 259, (8 January 1993) pages 188-194 and Foster, P. *Directd Mutation: Between Unicorns and Goats, Journal of Bacteriology*, March 1992, pages 1711-6.

[423] Pollard J., *New Genetic Mechanisms and Their Implication for the Formation of New Species*, pages 63 and 69.

no data on the mode of germ-cell development are available."[424] It would be fair to say that for the majority of organisms living on Earth today have somatic determination or late germ line segregation. This preponderance is explained by the fact that organisms with no, or virtually non-existent germ line segregation, can in principle, directly and continuously accumulate inherited variation resulting in species richer in number and diversity.[425]

Even in animals with early germ line segregation environmental changes at an early "embryonic stage"[426] may effect both somatic and germ line cells. This usually occurs at a specific "period of an individual's life, when reproductive cells are specially sensitive to new impressions."[427]

Weismann hypothesised that, these instances of the transmission of inherited characters were due to the germ line cell lineage itself being affected in early development before their sequestration. Kropotkin, with very little substantiating evidence, argues that it was more plausible that this resulted from the influence of somatic cells upon the germ-plasm. At the time, due to technological restrictions, it was not possible to prove the validity of either of the "two possible interpretations", either his own or that of Weismann's. However, either way, Kropotkin observes, in animals, "the *fact* of transmission of changes acquired in one generation to the next remains."[428]

It is now known that that some acquired changes in "organisms such as mammals...can transmit to the next generation", but "only" when, as suggested by

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[424] *Epigenetic Inheritance and Evolution*, page 43.

[425] Buss, L.W. *Diversification and Germ-Line Determination*. Paleobiology 14 (1988), pages 313-21.

[426] Kropotkin, *Evolution and Environment*, Quebec, Black Rose Books, 1995, page 176.

[427] *The Direct Action Of Environment And Evolution*, The Nineteenth Century And After, Vol 85 (1919), page 79.

[428] Kropotkin, Evolution and Environment, Quebec, Black Rose Books, 1995, page 232.

Weismann, these “new variations...occur either before germ line segregation, or in the germ line itself.”[429]

Pest-insect populations rapidly and seemingly directly adapt to the toxins directed at them. “Resistance often involves the amplification of genes-encoding enzymes that detoxify the chemical”, by increasing the rate at which they are pumped out of the cell.[430] Gene amplification is an epigenetic process, which increases the number of copies of particular genes or a sequence of DNA, in a genome, in this case, in the germ line cells. DNA developed to counteract toxicity in symbiotic bacteria living within the insect or free living bacteria in the soil may also infect insect’s germ line chromosomes via transduction by mobile genetic agents.

> “Toxic chemicals in the environment stabilize those cells in which the genes for the appropriate detoxifying enzymes are being amplified. In that respect, the environmental agents is selecting for a physiological response, but not for a pre-existing genetic variant…Such instances of directed variations demonstrate that the organism respond physiologically to the environment in one *continuous* process. The environment is ‘selective’ in so far as it selects, via the physiological system for an appropriate response, but no real ‘selective deaths’ have taken place as required by natural selection. The fact that the response may involve genomic changes shows that the strict dichotomy between genotype and phenotype really does not exist as far as the organism is concerned.”[431]

Experiments with mammalian cells revealed that “cultured cells selectively amplify specific genes in response to drugs or other toxic substances.”[432] Families of human farmers poisoned by insecticides, have been found to have a “100-fold amplification” of a particular ‘silent’ gene, which was believed to have been

[429] *Epigenetic Inheritance and Evolution*, page 152.
[430] Ho, *Gentetic Engineering* page 136.
[431] Ho, *On Not Holding Nature Still: Evolution by Process, Not by Consequence*, in Ho and Fox (eds) *Evolutionary Processes and Metaphors*, page 130.
[432] *Epigenetic Inheritance and Evolution*, page 69.

transmitted from the father to the son and have originated “during spermatogenesis”.[433]

The environment does induce direct physiological effects in animals. An old and well known example is the lessening (whitening) of pigmentation in response to a decline in humidity. Kropotkin speculated that, the polar bear and other alpine animals became white as a physiological response and not from the natural selection of accidental variation. An old study of American doves showed:

> “The point of least pigmentation coincides with the area of lowest humidity and increases in either direction as the humidity increases. By exposing the lightly pigmented form to very humid conditions, it was demonstrated that pigment was acquired gradually through a series of moults till finally a stage was reached which was darker than any known in nature.”[434]

Behavioural changes, especially those involving a change of diet or environment often causes considerable stress. Genomes usually remain relatively stable, but, during times of environmental stress rapid restructuring often occurs:

> “genomic organisation is infinitely more complex and much more liable to dramatic changes than previously conceived. There exist a complete set of enzymes capable of restructuring the genome both within the life-span of an organism and throughout evolutionary time.”[435]

Domestication of mammal species also alters gene expression leading to the activation of silenced genes. Studies of silver foxes revealed that, domestication releases a “spectrum of dormant genes” from silencing; changing their heritable state by making them “heritably active.” Factors such as: selection for tameness, density of population, constant temperature etc., leads to a host of profound behavioural and epi-genetic changes. Examples include, changing the timing of moulting or greatly

[433] Ibid, page 70.
[434] Ho, *Environment, Heredity and Development,* in *Beyond Neo Darwinism,* page 271.
[435] Pollard J., *New Genetic Mechanisms and Their Implication for the Formation of New Species,* in Ho and Fox (eds) *Evolutionary Processes and Metaphors*, pages 63-4.

lengthening or inducing an additional reproductive season. It is suggested that, the artificial environment causes substantial hormonal changes inducing unusual modifications. Although during early development there are mechanisms for re-setting epigenetic marks or information, they are sometimes inheritable.

Although many of these inheritable epigenetic variations observed in animals are "quantitative" (as in amplification) rather than "qualitative" changes this does not necessarily imply that they are always likely to have only small effects:

> "Many gene amplifications result in visible alterations to chromosome structure…unrelated or related genes may be amplified in concert with genes whose product confers a selective advantage resulting in unexpected effects on phenotype. During amplification, the particular sequence amplified at each successive step can differ and novel rearrangements can also occur which may bring together disparate parts of the genome"[436]

Transposition may also have wide ranging and unpredictable affects:

> "For transposable elements to have evolutionary consequences, it is not necessary for them to carry 'foreign genetic' information, because they can cause substantial genetic effects on their own over and above their mutational capacity…These sequences are a major source of new mutation; they provide sites for recombination or conversion with other genes in a gene family, act as a means of dispersing sequences to other chromosomes and increase genetic variability by their mode of replication…Germline transposition could result in the re-setting of developmental pathways and their timing of expression, perhaps giving new forms *ab initio*."[437]

Such stress induced genomic responses as transposition and amplification can lead to "rapid and dramatic phenotypic effects". Thus in small populations in a new environment, whose genes amplify due to toxins in a new diet or because stress makes them more susceptible to large scale genomic disruption following genetic invasion may be a major cause of speciation in mammals. Such a thesis is compatible

[436] Pollard J., *New Genetic Mechanisms and Their Implication for the Formation of New Species,* page 70.

[437] Pollard J., *New Genetic Mechanisms and Their Implication for the Formation of New Species,* pages 74-5.

with the currently popular “punctuated mode of speciation” whilst “harmonization of elements accounts for stasis”[438]

Epigenetic changes may be fixed by the genomic substructure. Although this may be much more true for plants, and other organisms without a segregated or late-segregating germ line.

More generally, the epigenetic or chromatin marking system, has important multi-dimensional organisational capabilities. Heritable chromatin variants evolved as a repair and defence system. As in bacteria, selection has strongly favoured genomes capable of repairing errors and silencing or deactivating genetic parasites and damage caused by them or other environmental factors. In addition to this, chromatin marks influence the expression and timing of chromosomal interactions. The combination of these important overlapping processes, Jablonka and Lamb speculate may create mutational ‘hot spots’. Active chromatin may facilitate insertion of mobile genetic elements. Chromatin variants may also alter the frequency of meiotic recombination thereby creating novelty and speciation through generating chromosomal incompatibility between populations.[439]

> “...an almost inevitable consequence of the evolution of DNA repair and defence systems, which are needed for genetic homeostasis, was the evolution of internal genetic-engineering systems that could overcome genetic homeostasis. For example, repair enzymes, so important for correcting damage and for defence against genetic parasites, can also perform other tasks: they can recombine DNA motifs and rearrange the chromosome. The homeostatic mechanism of repair and defence became a kind of Trojan horse, enabling the creation of a new kind of heritable variation...the DNA motif, not the base composition of that motif”[440]

[438] Ibid, page 77.
[439] *Epigenetic Inheritance and Evolution*, page 160-8.
[440] Ibid, page 284.

Although again, *highly speculative,* it is also suggested by Jablonka and Lamb as well as Pollard[441] that success of a particular stimulus-dependant phenotype in new environments could lead to the canalisation or genetic fixing of this phenotype sometimes resulting in heterochronic changes; that is, alterations in developmental timing. The idea that heterochronic changes can produce new species is currently a very popular one and is probably a major cause of large mutations responsible for speciation in mammals and other animals, with complex developmental processes and early germ line segregation. Because changes in developmental timing can affect many things all at once it can be persuasively argued (as Goldschmidt did in the 1930s) that, it is very much more likely to "produce a fairly co-ordinated novel organism"[442]. For example, human features resemble that of an ape's foetus, and it is considered most probable that we evolved as a result of alterations in developmental timing early in embryogenesis within an ancestral ape population.

Although asexual reproduction is uncommon in animals, when it occurs, possibilities for transmission of environmentally induced characters are substantial. Aphids have parthenogenic generations (reproduction by female alone from an unfertilised egg). Laboratory experiments have shown that, epigenetic changes influencing food preferences are heritable. Experiments involving the rearing of successive generations of aphids on different and unpalatable host plants showed how they eventually adapted their new diet/host plant, even, when initially it was totally rejected. Morphological changes were observed. Although mating occurred

[441] Pollard J., *New Genetic Mechanisms and Their Implication for the Formation of New Species,* pages 66-7, ibid, page 63.

[442] *Epigenetic Inheritance and Evolution*, page 222. For an overview of this thesis, see Gould, S. J. *Ontogeny and Phylogeny*, Cambridge Mass., 1977.

between the new varieties and the original aphid population, only a very small percentage of the eggs were viable. More remarkable was that:

> "not only did [the aphids] acquire a new host preference, morphological differences, and reproductive isolation from its sister clone, but, it also had adaptive morphological features that made it converge with the species that usually lives on the host to which it had been adapted. Even more remarkably, the newly adapted strain produced fertile progeny with [it]..."[443]

There are also many examples of 'species flocking' where rapid and prolific speciation occurs sympatrically in an isolated novel environment. Species flocking shows that phenotypic and behavioural diversity can lead to rapid speciation. Although mainly occurring in small animals it is also found among fish and birds. A well known example is that of the chichlid fish of Africa:

> "The chichlid fishes of Lake Victoria provide a remarkable of the diversity that is made possible by recombinations. The cichlid fish have diversified dramatically, producing some species that look like catfish, others that swim about in the plankton like whales, others that only eat other fishes eyes, others that eat only the babies from other fishes mouths, others that eat only the scales off other fish. They are all specialised in differing ways. They appear to have made as much evolutionary diversity in half a million years as the fish of Lake Malawi have in three million years. Yet, the degree of genetic variability among these Victoria cichlid is the same as that among people, a mere 1%. Their phenotypic diversity is enormous even though their genetic diversity is very small."[444]

Kropotkin assertion that the environment is an important source of variation, which is inheritable through a variety of genetic and non-genetic mechanisms, despite being disregarded for most of the 20th century, is again beginning to be taken very much more seriously, though the answer to exactly how important these non-genetic inheritance and variation systems are, in evolution, has yet to be adequately determined.

[443] Jablonka E and Lamb M. *Epigenetic Inheritance and Evolution*, Oxford, Oxford University Press, 1995, page 238.

[444] Cohen J., *The Complexity of Evolution*, pages 355-6

Symbiosis-Symbiogenesis and Inheritance of Acquired Characters:

in 1878 the plant pathologist, Anton de Bary, invented the term symbiosis. But, there were many pioneers of symbiosis research around this period, in Russia, France, England, Germany and America. The notion of "Symbiogenesis" (evolution by speciation events resulting from symbiosis) was first developed in the late 19th century. The term was coined by Merezhkovskii in 1909.

Kropotkin maintained professional and personal relationships with scientists who were involved in symbiosis research. Patrick Geddes, for example, with whom Kropotkin corresponded, published in *Nature*, in 1882 an article on "reciprocal accommodation" of plant symbionts in sea anemones. Kropotkin maintained a long and warm correspondence with the French biologist, Marie Goldsmith who collaborated and co-authored books and articles with Yves Delage, an esteemed biologist and zoologist at the Sorbone. Delage and Goldsmith investigated and discussed symbiotic relationships in legumes (with nitrogen fixing bacteria), orchids and trees (with fungi) and unicellular algae with the 'lower animals'.[445] Goldsmith and Yves Delage thought very highly of Kropotkin and included a summary of his views in a section of their influential and widely read book, *The Theories of Evolution*.[446]

Jablonka and Lamb conclude that: "Natural selection, acting on sequence composition, seems to be fairly ineffective unless there is a major genomic change that breaks…the straitjacket of genetic homeostasis". One way that this occurs is by the "introduction of a new genome through symbiosis."[447]

[445] Jan Sapp, *Evolution by Association: A History of Symbiosis*, New York, Oxford University Press, 1994, page 76.

[446] Goldsmith, M., and Yves Delage, *The Theories of Evolution* (1909) New York: B.W. Huebsch, 1912 pages 347-52

[447] *Epigenetic Inheritance and Evolution*, pages 283-4.

The terms mutualism and symbiosis are often used interchangeably or in a confused way.[448] In the following, mutualism refers to co-operative behaviour between individuals of the same species and symbiosis refers to intimate and long-lasting (though not necessarily mutually beneficial[449]) physical relationships between individuals of different species.[450]

Major emergent evolutionary events have resulted from symbiotic convergences or amalgamations; the association or integration of two (or more) phylogenetically distinct genomes leading to the formation of novel organisms and ecosystems. Evolutionary tree pictures with man at the top of pyramid like tree have been replaced by representations, as Darwin himself pictured, akin to an intricate multi-twigged well-trimmed shrub, exhibiting no overt hierarchy. Symbiosis presents an evolutionary picture comparable to the rainforest strangler fig whose tendrils not only depart from one another but join again as well.

Kropotkin kept abreast of developments in symbiosis. In two articles upon the evolution and physiology of nucleated cells, Kropotkin concludes that, the

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[448] Boucher for example in his pioneering article on the history of the mutual aid idea, 'The idea of mutualism, past and present' in *The Biology of Mutualism*, (ed. Boucher, pages 1-28, Croom Helm, London 1965) uses the term mutualism to describe all mutually beneficial symbiotic relationships. The term mutualistic symbiosis is used by a number of authors in Lynn Margulis and Rene Fester (eds.), *Symbiosis as a Source of Evolutionary Innovation: Speciation and Morphogenesis*, Massachusetts, MIT Press, 1991, for types of symbiosis that have obvious benefits for both partners or who are not in close contact with each other. The term inter-specific mutualism is used by Wynne-Edwards (1986) to describe mutually beneficial relationships between different species in the same environment which do not have close physical contact. One could go on and on but for the purposes of this discussion I am not going to spend unnecessary pages on this ongoing muddle of biological nomenclature.

[449] Many symbiotic relationships most probably began as parasitic or pathogenic invasions, which were later modified. Some symbiotic relationships, for example, mycorrhizal associations between plant roots and fungi can be beneficial or harmful to their hosts depending upon environmental conditions. See Angela Douglas, *Symbiotic Interactions*, New York, Oxford University Press, 1994, pages 2-7.

[450]The related terms Commensalism and Phoresy are also employed by biologists to refer to similar, but different sorts of relationships to those of mutualism and symbiosis: "Commensalism (from the Latin, meaning eating from the same table) describes tow species of organisms physically associated with each other but deriving nutrients from a third (for example, clownfish and sea anemones feeding on bacterial symbionts). Phoresy [from the Gk to bear] is used to describe the carrying of one organism by another(for example, remoras by sharks)" Lynn Margulis, *Slanted Truths: Essays on Symbiosis and Evolution*, New York, Springer-Verlag, 1997, pages 297-98.

various organs of the cell are "independent" and "separate organisms". Like the cell they "multiply only by subdivision".[451] He was attracted to Altman's 'co-operative colony' characterisation of the cell in which the evolution and functioning of the nucleus and cell is conceived as resulting from the co-operation of once free living microbes:

> "As to the cell, it is not, in Altmann's view, an elementary organism, but a *colony* of elementary organisms which group together according to certain rules of colonisation. They constitute the protoplasm as well as the nuclear plasm, and they are the morphological units of living matter. These granules, he maintains, are identical with microbes; their shape, their chemical reactions, their movements, and their secretory functions are similar; but the granules of the protoplasm differ from bacteria in not being capable of a separate existence. They can only live in cells"[452]

In another article Kropotkin surveys the agricultural and ecological importance of symbiotic relationships that plants have with bacteria. Although the focus is upon nitrogen fixing bacteria he also discusses mycorrhizal fungi and their importance to the health of trees. He also discusses the discovery of sulphur and iron feeding bacteria in the Black Sea and their geological and ecological importance:

> "All these are evidently but separate instances of a much more general fact, which only recently became known under the general name of 'symbiosis' and appears to have an immense signification in nature. Higher plants depend upon lower fungi and bacteria for the supply of that important part of their tissues, nitrogen. Lower fungi associate with unicellular algae to form that great division of the vegetable world, the lichens. More than a hundred different species of algae are already known to live in the tissues of other plants, and even in the tissues and the cells of animals, and to render each other mutual services. And so on. Associations of high and low organisms are discovered every day; and when their conditions of life are more closely examined, the whole cycle of life changes its aspect and acquires a much deeper signification."[453]

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[451] Kropotkin, *Recent Science*, December 1892, page 111-4.
[452] Ibid, page 756-9.
[453] Kropotkin, *Recent Science*, August 1893, page 266.

"At the present time, we know that no animal or plant, with the exception of the lowest unicellular beings, can be considered as one being—that each of them is a colony of multitude of micro-organisms"[454]

Though these concepts were developed nearly a century ago, the symbiogenesis theory of the evolution of the cell was unknown, ignored or denied by most leading researchers in the life sciences for much of the 20th century. The application of nucleotide sequence analysis to cytoplasmic genomes has proved beyond doubt the symbiotic origin of the nucleated cell. There has been a revolution in the understanding of symbiosis in evolution and ecology within the scientific establishment.[455]

Serial endosymbiosis explains the evolution of eukaryotic cells (cells in which genetic material is contained within a distinct membrane-bounded nucleus) from bacteria in the later pre-Cambrian as a result of a succession or series of multi-staged mergers of prokaryotic cells (i.e. bacteria that lack membrane bounded nuclei). Two eukaryotic cytoplasmic organelles, plastids and mitochondria evolved symbiotically. They are now the parts of the cell allowing plants to photosynthesise and ourselves to respire: mitochondria and plastids. These organelles have translation machinery (ie. ribosomes, tRNAs, etc. for protein synthesis) distinct from the nucleocytoplasm, and the sequences of organelle genes, such as rRNA genes, are more closely allied with eubacteria than eukaryotes"[456]

Because unicellular protists reproduce by division, similar but far less dramatic symbiogenesis events have been observed in amoeba under laboratory conditions:

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[454] Kropotkin, *Recent Science*, August 1893, page 261.

[455] A history of Symbiosis research and theorising can be found in Jan Sapp's *Evolution by Association* and L.N. Khakhina, *Concepts of Symbiogenesis: A Historical and Critical Study of the Research of Russian Botanists*, New Haven, Yale University Press, 1992.

[456] *Symbiotic Interactions*, pages 124-32 passim.

"There is a remarkable series of observations and experiments on the establishment of a symbiosis in a protist with no known history of such interaction. Jeon and co-workers have investigated the bacterial parasitism of *Amoeba proteus* and the rapid transition from necrotrophic parasite to obligate heritable symbiont. Initially, amoebae were killed by an unknown species of obligately parasitic bacteria; however, both taxa are now obligate symbionts, and natural selection acts upon them as a unit. The symbiontic association exhibits a new temperature and antibiotic sensitivity and slower growth. One selective advantage of the symbiosis may lie in the ability of the bacteria to kill non-resistant amoebae. This may provide a competitive advantage comparable to the killer trait that *Paramecium* derives from *Caedibacter*....When the partner of the amoeba/bacteria symbiosis are considered as a unit, the rate and size of the change are especially striking. The *Amoeba proteus* endosymbiont, if typical of other bacteria, would contain approximately 3000-5000 genes, many of them novel to the amoeba. Furthermore each gene is amplified by the great numbers of individual bacteria (up to 100, 000) infecting each amoeba. Such large and rapid genetic changes have been likened to Goldschmidt's concept of a "Hopeful Monster" and are suggestive of one possible mechanism for the discontinuous appearance of species described by Eldredge and Gould. Requiring only 200 generations, the evolution of this interaction between amoebae and bacteria from host and parasite to mutually dependent symbionts occurs rapidly, and does not necessarily involve gradual evolution of bacterial genes. Rather, the bacterium is acquired *in toto* as the result of hereditary symbiosis. Hereditary symbiosis, then by virtue of the establishment of relationships resulting in the acquisition of entire genomes, is by definition a form of macroevolutionary saltation....Acquisition of a symbiont can be distinguished form a mere correlate or consequence of a speciation event by examination of the importance of that symbiont or symbiosis to that taxon. In the case of a new species, this may be difficult or impossible. However, in the case where a species generates a number of new species, all of which contain the symbiont, and where the symbiont is a distinguishing characteristic and is crucial to the new taxon, it can then be inferred with some confidence that the symbiosis was directly involved in the process of speciation and, through the generation on new species, with origin of new higher taxa."[457]

Symbiotic associations with fungi allowed plants (the primary production of food for animals) to colonize land. Symbiosis has been integral to the evolutionary

[457] David Bermudes and Richard Back, *Symbiosis Inferred from the fossil Record*, Symbiosis as a Source of Evolutionary Innovation, page 81.

development and ecological basis and maintenance of some marine ecosystems and virtually all terrestrial ones:

> "Symbioses are of particular importance in the utilization of photosynthetic carbon and the relationship between primary producers (plants, algae and cyanobacteria) and their consumers. Let us consider algae and cyanobacteria first. A variety of aquatic protists and animals, and animals, and the lichenized fungi on land, form symbioses with algae and cyanobacteria. Up to 90 per cent of the photosynthate (ie., net primary production) of the symbionts is transferred biotrophically from living cells of the photosynthetic partner to the heterotrophic hosts. Some of the associations are of considerable ecological importance. For example, lichens are most important primary producers in habitats covering 8 per cent of the land surface; these include Antarctica, many Arctic—alpine habitats, and some desserts. A second example is the coral-alga symbiosis, which underpins all coral reef ecosystems. The primary productivity of coral reefs is two orders of magnitude greater than open tropical waters. On a global basis the algae in corals fix 3-4 times more carbon than the phytoplankton in all the nutrient upwelling regions of the open ocean. Terrestrial plants are also utilized biotrophically through symbiosis...More than 90 per cent of plant species in tropical forests (both rainforests and seasonally dry forests) have mycorrhizal fungi, and mycorrhizal vegetation is the norm in temperate, and boreal forests, savanna, temperate grasslands, and Mediterranean-type habitats....It is also appropriate to examine the nature of primary producers. The plastids in algae and plants can be considered to obtain photsynthate through biotrophic symbiosis, in the same way as in symbioses of algae or cyanobacteria with lichenized fungi or corals. From this standpoint virtually all primary production on land is symbiotic....Nitrogen-fixing bacteria and mycorrhizal fungi associated with plants play a crucial role in the nitrogen and phosphorus cycles in terrestrial ecosystems."[458]

Symbiogenesis is not so much the influence of the environment but the wholesale incorporation of living organisms of the surrounding environment into another organism, that can, in exceptional, but in evolutionary terms, highly significant speciation events, lead to the eventual development of whole classes of organisms.

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[458] *Symbiotic Interactions*, pages 112-114 passim.

Because of the sexual nature of animal reproduction the horizontal mechanisms of symbiotic inheritance which occurs between bacteria and protists are not so easily available to them. However, this does not prevent other methods of cytoplasmic and extra-cytoplasmic inheritance of acquired symbionts, especially in insects:

> "The mycetocyte symbionts in insects are transferred from the mycetocytes [especially evolved cells in which to carry often essential symbiotic bacteria] of females to each egg developing in the ovaries. After fertilisation of the egg, the symbionts are retained with the embryo, and are finally allocated to the embryo's mycetocytes as these cells differentiate...In *Pediculus humanus* (human body louse) the mycetocytes are aggregated together as a coherent organ, the mycetome just ventral to the midgut. During the final moult of the insect, the bacteria are expelled from the mycetome of females and they migrate to the reproductive tract. The migration is rapid and is usually complete within 12 hours...A sample of bacteria is transferred from the pedicel into the cytoplasm of the basal egg in each ovariole, just before the egg is released into the oviduct. In this way, each egg is inoculated in turn with its mother's bacteria."[459]

One particular species of corn-weevil normally lives in a symbiotic relationship with bacteria from which it gains essential vitamins and other important nutritional requirements. Although the weevil can survive in the absence of the bacteria (i.e. not obligate) its vigour is severely reduced. However in wild populations on wild corn (much less nutritional than modern cultivars) they are never found with an absence of the symbionts. The development of super-varieties has led to the development of aposymbiotic populations: "the aposymbiotic adult weevils are softer and paler than symbiotic ones, and (probably as a consequence of the decreased energetic metabolism) they no longer fly."[460] Here the changing of the

[459] Ibid, page 79-80 passim.

[460] Paul Nardon and Anne-Marie Grenier, *Serial Endosymbiosis Theory and Weevil Evolution: The Role of Symbiosis*, Symbiosis as a Source of Evolutionary Innovation, page 159.

environment (re: more nutritious food) led to direct changes in the morphology of the weevil (because of the elimination of symbiotic bacteria) that were inheritable.

Many larger herbivorous mammals (and some herbivorous birds such as grouse and certain termites), and particularly in cows, elephants, kangaroos (and extinct herbivorous dinosaurs), which utilise masses of low grade fodder require specific microbiota in the gut to breakdown cellulose. The digestive systems of these animals have modified themselves in such a way to accommodate symbiotic bacteria. Indeed, herbivory and the ecosystems it supports are largely dependant upon the development such symbioses. Without bacteria this novel metabolic capability could not have evolved. Herbivorous dinosaurs evolved in the Mesozoic and mammalian herbivores in the Cenozoic period. These symbioses must have developed at the same time.[461] With larger animals, often with early germ-line determination, symbiosis, in addition to heterochrony is another way in which novelty, adaptation and speciation has been continually generated. Its difficult for animals in the course of their evolution to alter their genetic structure so as to be able to digest cellulose. This was achieved not by genetic change but through incorporating organisms possessing the required DNA. Through symbiosis species which are largely unable to pass on somatic variation are able to gain an incredible degree of plasticity. In herbivores the nature of the gut wall prevents vertical transmission to the eggs that occurs in Lice. In cattle the mother “licks her calf, ensuring the continuity of her entodiniomorph rumen ciliates.” Margulis continues: “The ‘standard’ neo-Darwinian evolutionary theory claims that cows evolved by ‘gradual accumulation of favourable mutations’ while it ignores the cellulytic activities of cow symbionts.”[462]

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[461] David Bermudes and Richard Back, *Symbiosis Inferred from the Fossil Record*, Symbiosis as a Source of Evolutionary Innovation, page 81.

[462] *Symbiosis as a Source of Evolutionary Innovation*, page 11.

Evidence suggests that the importance of symbiosis in evolution has been greatly underestimated:

> "28 of 75 phyla (excluding bacteria) possess symbiotically derived organelles unique to or defining the taxon that, have their appearance in the fossil record correlated with symbiosis, or consist largely or wholly of symbiotic members. Even if only partly true, this observation would indicate that symbiosis is a major force in evolution..."[463]

Adaptive Behaviour and Social Inheritance:

Animals are much less likely to adapt to environmental change. Migration is the normal response and extinction the most common outcome.

With regard to animals such as insects or mammals, Weismann's ideas are in some relevant respects, more or less correct.

Kropotkin believed that, because animals lacked the genetic plasticity of plants and bacteria they solved environmental challenges through behavioural change (behavioural phenotype). He examines a type of frog where the male of the species keeps the fertilised eggs attached to its legs until they hatch, protecting them from hot weather in his burrow. Subjected to an artificially higher temperature the frog changed its behaviour by abandoning the eggs.[464]

Kropotkin was particularly interested in the ability of animals to radically modify their behaviour in order to adapt to environmental change. Kropotkin was also interested in the ability of animals to pass behavioural innovation/information directly to offspring and other members of a social group. What higher animals lack in genetic and morphological inflexibility is compensated by instinctual flexibility and the ability to adopt and evolve novel behaviours.[465]

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[463] David Bermudes and Richard Back, *Symbiosis Inferred from the fossil Record,* Symbiosis as a Source of Evolutionary Innovation, page 81, pages 73-6 passim.

[464] Kropotkin, *Evolution and Environment*, Quebec, Black Rose Books, 1995, page 174.

[465] See discussion of alteration of habits and social cooperation in *Evolution and Environment*, page 142.

Memory and the ability to learn, communicate and instruct is an ability that developed very early on. Genomes, as well as the epigenetic differentiated states they participate in creating (somatic cell memory), are very complex and highly efficient memory systems. Bacterial cells "can compare the concentration of a chemical substance at two successive times; the ability to make this comparison has been termed memory".[466] The ability to learn and communicate is not restricted to animals with a complex nervous system: "We know that insects in general and bees in particular have excellent memories and an impressive ability to learn. We also know that a bee has very few neurones compared to even the smallest and most primitive vertebrate."[467]

Experiments comparing the ability of ants and rats to master the same maze reveals that, the ant's "ultimate performance is almost as good as that of the rats."[468] The differences in learning and communicative ability, between vertebrates and invertebrates, is "primarily quantitative".[469]

In European blackbirds collective mobbing of predators is instinctual. Experiments have shown that knowledge of which animal to mob is learned from others. The non-genetic or "behavioural transmission of information" allows for great plasticity and is an "incredibly clever way of getting around the upper limit to genetic complexity."[470] The plasticity of learned behaviour gives an organism selective advantages over those whose behaviour patterns are innate or fixed:

> "Evolutionary change involving the change in frequency of a particular gene is exceedingly slow...while a change in [behaviour] can occur in a matter of minutes or hours and does not even require a single generation. [Behavioural change] can also be passed on from parents to offspring for many generations

[466] Bonner, *The Evolution of Complexity*, New Jersey, Princeton Uni Press, 1988, page 201.
[467] Ibid, page 200.
[468] Ibid, page 204.
[469] Ibid, page 205.
[470] Ibid, page 218.

> and persist for a long time, but nothing prevents it from disappearing instantly should there be a sudden alteration in the environment"[471]
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> "The obvious advantage to such a plastic behaviour is that blackbirds, or any mobbing species, can quickly learn unfamiliar predators and don't require many generations of natural selection to be able to recognize a new danger. Another advantage is undoubtedly that, through memory, they can store more information and include all the different kinds of enemies they might have in one environment; behavioural memory can store more information than can easily be packed into the genes. Furthermore, it need store only the information that is relevant to a particular time an place to be adaptive."[472]
>
> "Another important feature of plasticity in behaviour is the capability of making inventions. We think of much of human historical progress as one invention succeeding another...but lesser animals are also capable of behavioural inventions than can be passed on, and there are some well-known examples: for instance, the tit in central Britain that learned how to peck open the milk bottles and take the cream at the top. This invention soon spread from one small area and now full milk bottles are not safe anywhere in the British Isles. As one might expect, primates are even better at inventing, and there have been many well-documented cases of a useful invention that the spreads in a population."[473]

Although it is traditional to regard inheritance in animals in genetic terms, in mammals and birds, the ability to pass on behavioural adaptation to the environment becomes increasingly important, and is, as Kropotkin also suggested, a directly inheritable adaptive response to the environment.

Conclusion

The natural selection of variation, in whatever way variation might come about, is a necessary mechanism in any plausible theory of evolution, though not a sufficient one.

It is necessary, as Kropotkin and the mature Darwin suggested, to supplement the notion of a single or unified system of inheritance and modification, that of the

[471] Ibid, page 209.
[472] Bonner, *The Evolution of Complexity*, New Jersey, Princeton Uni Press, 1988, page 214.
[473] Ibid, page 217.

survival of internally generated random mutations of hereditary material under natural selection. These additional modes of inheritance include, epigenetic, cytoplasmic, extra-cytoplasmic and behavioural systems involving the transmission of environmentally induced, acquired or adaptive modifications or information . This poses an intellectual threat to the neo-Darwinists, whom Kropotkin called "the vulgarisers of Darwin's teaching",[474] who still dominate evolutionary biology. The inclusion of several additional and more environmentally sensitive inheritance systems, enriches our understanding of evolution/speciation; expanding, broadening and supplementing, rather than threatening Darwin's theory of natural selection. It also brings our understanding of evolutionary processes closer to the historic Darwin, whom Kropotkin so admired.

[474] *The Direct Action Of Environment And Evolution*, The Nineteenth Century And After Vol 85 (1919), page 89.

Chapter 5

Kropotkin's Social Anarchism and its Environmental Dimensions

Social Evolution through Communal Revolution

Having shown that humans were social, indeed social before they were human, Kropotkin, in *Mutual Aid*, goes on to explore the development of human society, examining anthropological data from a large number of societies and cultures from all around the world. He examines customs, from those of the Bushmen and the Aborigines (who, although rich in culture, materially possessed nothing more than a stone axe and some pretty shells), to that of the suburban neighbourhood of modern industrial society. He concludes that humans have never been solitary and isolated from one another. Despite the numerous wars and conflicts between differing human groupings the general tendency of human evolution was essentially integrative and social in its orientation.

The common need for protection and company, as well as the economic interdependency of many human groupings of the past, had encouraged and nurtured the more generous and social aspects of human nature. Kropotkin argued that complex co-operative behaviour could be seen in relations between bush-people; the communal ownership and working of the land in the early horticultural and farming settlements; the early medieval city and in the 18th and 19th centuries the plethora of voluntary organisations and interest groups (e.g. The British Lifeboat Association, literary and artistic societies, cycling clubs, etc.). Such interest groups had sprung up in the course of everyday life in order to meet the many needs and requirements of human social and industrial life and were important examples of spontaneous, voluntary and highly organised human social activity and evolution.

From his examination of different societies, Kropotkin also concludes that, the urge to dominate and to impose one's will upon another has been as important a feature of human life as that of egalitarian and spontaneous co-operation. Differences in age, gender, strength and character had, however, also led to the development of hierarchies and individualism. These traits, Kropotkin asserts, had remained relatively harmless within the band or tribal structure. The activities of ambitious individuals had been continually moderated by the other members of the group in which they lived. The following quote, from Kropotkin's *The State: Its Historic Role*, is illustrative of his ideas concerning the development of hierarchy:

> “There is no doubt that primitive society had temporary leaders. The sorcerer, the rainmaker—the learned men of that age—sought to profit from what they knew about nature in order to dominate their fellow beings. Similarly, he who could more easily memorize the proverbs and songs in which all tradition was embodied became influential. At popular festivities he would recite these proverbs and songs in which were incorporated the decisions that had been taken on such and such an occasion by the people's assembly in such a connection. In many small tribes this is still done. And dating from that age, these "educated" members sought to ensure a dominant role for themselves by communicating their knowledge only to the chosen few, to the initiates. All religions, and even the arts and all trades have begun with "mysteries," and modern research demonstrates the important role that secret societies of the initiates play to maintain some traditional practices in primitive clans. Already the germs of authority are present there.
>
> It goes without saying that the courageous, the daring, and above all the prudent also became the temporary leaders in the struggles with other tribes or during migrations. But there was no alliance between the bearer of the "law" (the one

who knew by heart the tradition and past decisions), the military chief, and the sorcerer; and the state was no more part of these tribes than it is of the society of bees or ants, or of our contemporaries the Patagonians and the Eskimos."[475]

The effects of migration and inter-tribal conflict eventually led to the disappearance of tribal society. Humanity joined into much larger social groupings that were increasingly less dependent upon blood-ties. With the development of a warrior class and the division of labour, characteristic of larger societies, those individualistic and domineering character traits, which had remained for the most part relatively harmless in traditional tribal societies, became increasingly more dangerous—eventually leading to the development of church, state and Empire. The non-hierarchical, egalitarian and spontaneously social aspects of human co-association, far from disappearing, had however, continued to develop alongside, and sometimes in open conflict, with the evolution of hierarchy, centralised authority and imperialism. The communal and egalitarian customs of traditional village life of 19th century Europe and Asia, Kropotkin reminds us throughout his works, had survived, despite the development of ceasarism, monarchism and the totalitarian or state-capitalist era.

Thus, the history of societal evolution was of a two-fold nature. A compromise between two mutually hostile and widely differing forms of social organisation—the externally or centrally imposed authority of the monarch, feudal lord, military-state or empire and the autonomous and internally self-regulating city, village or community. Although these tendencies evolved side by side, changing and modifying themselves over time, there could exist no genuine or lasting equilibrium between them whilst the state continued to exist. The history of human social

[475] Kropotkin, *The State: Its Historic Role*, in Miller, *Selected Writings*, pages 217-8.

development was that of an uneasy truce, punctuated by violent revolutions and rebellions, during which the people asserted their social-evolutionary power. In these periods the masses sought to recover economic, social and political self-administration and redirect the course of history along non-statist, communal, federalist and egalitarian lines. The communal revolutions of 11th and 12th century Europe, the great French Revolution and the Paris Commune of 1871 were, Kropotkin maintained, important instances of social evolutionary eruption and conflict. These events representing dramatic evolutionary breaks when, because of one circumstance or another, humanity felt the need to allow for the free and creative forces of social evolution to assert themselves unhampered by the torpor of centralised hierarchical authority.

Kropotkin, despite his *narodnik* faith in the Russian *mir*[476] and love of Russian peasant life, did not envisage the "dissolution of the city" and the retribalisation or revillagisation of humanity (a view to which he has unfortunately all too often been accredited). Kropotkin appreciated the unique dimensions and the possibility for human freedom inherent in "free" urban or "municipal life".[477] The emergence of the city, and the weakening of the tribal or blood-bond of kinship, was a major turning point in human cultural evolution. It created a unique realm of civic and political space—the public arena or polis. The civic arena, although developing from the tribal or village gathering, was thus populated by an entirely new species of social and political animal, that of the citizen or resident, whose right to participate in the affairs of the city was dependent upon residence or adoption rather than a shared ethnic or cultural background. Unlike the state, which attempted to rule any number

[476] Mir is the name given to both the commune as well as the regular meetings of all the peasants in the village, where land etc., is periodically distributed.

[477] *Mutual Aid*, London, Heinemann, 1902; Popular Edition, 1915, pages 162-3.

of cities, towns and villages from London or Rome, the autonomous and self-governing city—like that of the village community—was a natural product of human social evolution. The autonomic and geographically defined city-region with its surrounding rural areas, villages and towns, represented the most obvious unit from which to organise modern social life. The true direction of social evolution lay in overthrowing the state which had sought to destroy regional diversity in its attempt to administer and exploit the entire known world from London, Paris or Berlin. True freedom and liberty could only be achieved by direct democracy within the context of the self-governing, regionally integrated and self-sufficient town, village and city-region. National assemblies and representative government, which claim absolute authority over vast areas of territory—that is, over many separate peoples and geographical regions—were and could only remain the product of the tyranny and violence of imperialism. The need and periodic urge to recover regional or local self-administration and civic vitality represented for Kropotkin one of the most important dynamics in the history of social evolutionary change.

The Medieval Commune

The first significant example of the human urge for self government after the collapse of the Roman Empire in Western Europe was in the communal revolutions of the 11th and 12th centuries. The need to resurrect independent and free communal life took, Kropotkin believed, a dramatic leap at the end of the Dark Ages. Just when the "last vestiges of Barbarian freedom seemed to disappear", and the creative forces of European life had become stifled under the "dominion of a thousand petty rulers", the free and spontaneous forces of the people, utilising the protection of their town walls, "rose against the lord's castle" and, in less than a century, covered Europe with free and independent cities.[478] Although the free and independent city eventually fell prey to the feudal lord through developing a class structure and "estranging" itself from the countryside[479] (the crystallisation of the feudal epoch), the early medieval commune nonetheless represented a significant social attempt to assume local and independent community control.

The importance of the sovereign medieval city in anarchist theory was, Kropotkin maintained, that they were not organised according to some "preconceived plan" or mould "in obedience to the will of an outside legislator”. [480] Rather, they were the organic and "natural growth" of free and independent social evolution. Moreover, unlike the modern provincial city, which is merely a subordinate and semi-autonomous particle of the nation-state, the medieval commune was a distinct, well-integrated and self-administrative social unit. It had the absolute "right of war and peace, of federation and alliance with its neighbours”.[481]

The intense sociality and unity of early medieval city life had left forms of community-inspired art and architecture which surpassed even the grandeur of their Greek predecessors. For unlike the Acropolis, “a solitary effort to which thousands of slaves would have contributed the share assigned to them by one man’s imagination”, the medieval city was the result of a vast communal effort to which every one had “contributed”. The great buildings of medieval Europe, unlike the “meaningless scaffold” of the Eiffel Tower, “sprang out of a conception of brotherhood and unity” and expressed not the vision of a solitary individual but, rather, “the glory of each citizen in a city of his own creation”.[482]

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[478]*Mutual Aid*, pages 124-5.
[479] *Mutual Aid*, page 165.
[480] Ibid, page 142.
[481] Ibid, page 136.
[482] *Mutual Aid*, page 159.

Art, at present confined to the national gallery or theatre, was within the medieval commune, an integral and integrated part of the living human community. The Louvre, Kropotkin felt, was comparable to an “old curiosity shop”, a strange mixture of art objects, deprived of meaning and ruthlessly uprooted from the place and culture in which and for which they had been originally created. (This, incidentally, provides one of the most compelling arguments why the Elgin Marbles should be returned to the Athenians.) The medieval artisan had in the past appealed to his fellow citizens, in turn receiving purpose and inspiration from them. The popular monuments of the old cities appealed to the people as they embodied, indeed expressed, “the spirit and heart of the city”. Medieval art was not destined for sale or “stifled beneath the red cloth hangings of the Louvre”; it represented and surrounded the living community and entered into every manifestation of collective and communal life—its agriculture and industry, its hospitals and public buildings.[483] (For example, the landscape of rural England, a subtle patchwork of hedgerows, copses and meadows, can be considered as a socially created art form.)

William Morris, that most incurable of 19th century romantics and sometime associate of Kropotkin, unfortunately wielded far too much influence upon the latter. Kropotkin’s intensely artistic nature, populist leanings, aristocratic upbringing and the relative backwardness of his Mother Russia (from which he was exiled) irresistibly drew him to taking an overly romantic view of the early years of the middle ages. Civic art and life, he declares, “stood at its highest” during the first few centuries of medieval Europe.[484] It is important to understand, however, that this

[483] *The Conquest of Bread,* London, Chapman and Hall, 1906, Ch.IX, Pt. V. See also Andre Reszler, "Peter Kropotkin and his Vision of Anarchist Aesthetics", *Diogenes,* 78, pages 52-63; Kropotkin, *In Memory of William Morris,* Freedom, London, November 1896, pages 1-2; and Egbert, D.D., *Social Radicalism and the Arts in Western Europe,* New York, 1970.

[484] *Mutual Aid,* page 147.

rhetoric was designed to counteract the popularly held view that the dark ages and the later medieval period were characterised by constant war, strife, famine and disease. Moreover, those who have had the chance of living within or simply passing through a walled medieval city, such as Siena, cannot but be impressed by the grandeur and beauty of its public buildings (many of which took several generations to complete) and the architectural and organic unity of form that permeates the city as whole. As Lewis Mumford, who had great respect for Kropotkin, notes:

> ". . . a medieval town is like a medieval tapestry: the eye, challenged by the rich intricacy of the design, roams back and forth over the entire fabric, captivated by a flower, an animal, a head, lingering where it pleases, retracing its path, taking the whole only by the assimilating of its parts, not commanding the design at a single glance."[485]

Kropotkin's interest in the medieval commune was not, however, merely one of aesthetic theory, artistic preference and romantic medievalism. The unique forms of social and economic organisation developed by and within the medieval commune also provided glimpses of anarchist landscape. The segmentary and federative aspects of medieval cityscape were of particular importance in this respect. The regional spacing of independent cities and the consequent absence of "territorial centralisation " (macro-space organisation) was complemented (internally) within the city (micro-space organisation) by a non-centralised, segmentary though distinctively federative union consisting of a multiplicity of semi-autonomous sectional units. The medieval city, which had begun its life as a "simple" and crudely federated agglomeration of small villages enclosed behind a protective, one might say, cell-like wall, had in the course of its evolution retained and developed a distinctly

[485]Mumford quoted in Murray Bookchin, *The Limits of the City,* Montreal, Black Rose Books, 1986, page 123.

segmentary cityscape. Correspondingly, each section or segment tended to specialise in a particular trade or profession, creating a segmented though unified city, which, although capturing the civic harmoniousness of ancient Athens, was not dependent upon slavery and represented a socio-spatial formation distinct from that of the Greek city state:

> "The . . . Medieval City was not a Centralized State. During the first centuries of its existence, the city hardly could be named a State as regards its interior organization, because the Middle Ages knew no more of the present centralization or functions than of the present territorial centralization. Each group had its share of sovereignty. The city was usually divided into four quarters, or into five to seven sections radiating from a centre, each quarter or section roughly corresponding to a certain trade or profession which prevailed in it, but nevertheless containing inhabitants of different social positions and occupations; each section or quarter constituting a quite independent agglomeration.
>
> And if we refer to the annals of the Russian cities, Novgorod and Pskov, both of which are relatively rich in local details, we find the section *(konets)* consisting of independent streets *(ulitsa),* each of which though chiefly peopled with artisans of a certain craft, had also merchants and landowners among its inhabitants, and was a separate community. It had the communal responsibility of all members in case of crime, its own jurisdiction and administration by street aldermen *(ulichanskiye starosty),* its own seal and, in case of need, its own forum; its own militia, as also its self-elected priests and its own collective life and enterprise.
>
> The medieval city thus appears as a double federation: of all householders united into small territorial unions—the street, the parish, the section—and of individuals united by oath into guilds according to their professions; the former being a product of the village-community origin of the city, while the second was a subsequent growth called to life by new conditions . . .

In short, the more we begin to know the medieval city, the more we see that it was not simply a political organization for the protection of certain political liberties. It was an attempt at organizing, on a much grander scale than in a village community, a close union for mutual aid and support, for consumption and production, and for social life altogether, without imposing upon men the fetters of the State, but giving full liberty of expression to the creative genius of each separate group of individuals in art, crafts, science, commerce, and political organization."[486]

The French Revolution (1789-93) and the Commune of Paris (1871)

With the decline of the free city and the crystallisation of the feudal epoch the human capacity for free and voluntary engroupment was again fettered by the brutalising despotism of a thousand petty rulers. And again, believed Kropotkin, the urge for communal self-administration and determination provided the dynamic for the final destruction of the *ancien régime.* The great French Revolution was primarily a communal one. The urban and peasant commune prior to the reaction of 1793 performed the constructive work necessary for the development of new social formations which were required to meet the needs of a rapidly changing society. In every town, village and city it was "the commune which took from the lords the lands that were formerly communal". "The soul of the Revolution was therefore in the Communes", continues Kropotkin;

". . . and without these centers, scattered all over the land, the Revolution never would have had the power to overthrow the old *régime,* to repel the German invasion, and to regenerate France.

It would, however, be erroneous to represent the Communes of that time as modern municipal bodies, to which the citizens, after a few days of excitement during the elections, innocently confide the administration of all their business,

[486]*Mutual Aid,* pages 136-141.

> without taking themselves any further part in it. The foolish confidence in representative government, which characterises our own epoch, did not exist during the Great Revolution. The Commune which sprang from the popular movement was not separated from the people. By the intervention of its "districts", "sections" or "tribes", constituted as so many mediums of popular administration, it remained of the people, and this is what made the revolutionary power of these organisations.
>
> Governmental centralisation came later, but the Revolution began by creating the Commune—autonomous to a very great degree—and through this institution it gained immense power."[487]

The Commune of Paris in the great French Revolution, Kropotkin maintained, represented the most striking and well-documented example of this phenomenon. In Paris the lessons of the medieval commune—segmentation, unity and self-administration—were *transferred* under the "stress of immediate need" *into a new urban milieu.* The numerous districts and sections of Paris began to organise themselves on an individual basis creating, we are told, great independence and variety in their organisation . The essential and organic unity of Paris was however preserved by means of a federative "union" or "compact". Sigismond Lacroix (whom Kropotkin quotes at length) in his *Actes de la Commune* says:

> "The state of mind of the districts . . . displayed itself both by a very strong sentiment of communal unity and by a no less strong tendency towards direct self-government. Paris did not want to be a federation of sixty republics cut off haphazard each in its territory; the Commune is a unity composed of its united districts . . . Nowhere is there found a single example of a district setting itself up to live apart from the others . . . But side by side with this undisputed principle, another principle is disclosed . . . which is, that the Commune must legislate and administer for itself, directly, as much as possible. Government by representation

[487] *The Great French Revolution*, London, Heinemann, 1909, pages 180-181.

> must be reduced to a minimum; everything that the Commune can do directly must be done by it, without any intermediary, without any delegation, or else it may be done by delegates reduced to the rôle of special commissioners, acting under the uninterrupted control of those who have commissioned them . . . the final right of legislating and administrating for the Commune belongs to the districts—to the citizens, who come together in the general assemblies of the districts."[488]

Thus again in Paris during the French Revolution we see the re-emergence of the well-integrated city displaying a multiplicity of disintegrative forces yet managing to maintain a rich vein of civic participation while at the same time retaining and conveying a unified or total image. This distinctly urban form of localism akin to the notion of our modern neighbourhood councils, although evolving from ideas and practices sometime current within the medieval commune, nonetheless represented a considerable departure from its historical antecedent. The formation of a more urbanised city environment demanded new forms of political and urban landscapes.

The Paris Commune of 1871 (occurring nearly 80 years after the suppression of the Sections by the Commission for Public Safety in 1793) was for Kropotkin yet another heroic attempt by the citizens of Paris (et al) to recover the vast areas of civic domain lost to them in the decline of the medieval free city and in the reaction of 1793:

> "One cry broke from a hundred thousand breasts—"La Commune!" and on March 18, 1871, the people of Paris rose against a despised and detested government, and proclaimed the city independent, free, belonging to itself.
>
> This overthrow of the central power took place without the usual stage effects of revolution, without the firing of guns, without the shedding of blood

[488] Ibid, pages 183-184.

upon barricades. When the armed people came out into the streets, the rulers fled away, the troops evacuated the town, the civil functionaries hurriedly retreated to Versailles carrying everything they could with them. The government evaporated like a pond of stagnant water in a spring breeze, and on the nineteenth the great city of Paris found herself free from the impurity which had defiled her, with the loss of scarcely a drop of her children's blood.

In 1848, when the middle-class king, Louise Philippe, had been overthrown and left Paris in a hired cab, beneath the contempt of the great city, the first thing that the revolted workmen did was to nominate a Provisional Government for all France.

Now, (1871) a new principle was proclaimed. Paris said to the world that it did not pretend to govern France. The Paris workmen loudly announced that they should not wait until all France was ready for a social revolution, that they were willing to begin it within the walls of their own city. That each city, each village, was free to join the movement and to reconstitute those great federations of revolted communes which have played so immense a part in the history of civilisation in the twelfth century, as well as in starting the great Revolution of the 18th century.

But Paris did not pretend to give a government to France. Let each commune free itself first; then the freed communes will be brought to unite their efforts.

A great principle which has not died, notwithstanding the defeat of the Paris workmen. Nobody in France doubts that the next revolution will be made to the cry: *La Commune*, the independent commune, as the starting-point for the Social Revolution."[489]

Thus Kropotkin, like most socialists of his time, regarded the Paris Commune as a laboratory or test-tube example of (the second French!) Revolution. The anarchist revolution would necessarily be a communalist one consisting of innumerable uprisings of established communities. Communities who wished and

[489] *The Paris Commune*, Freedom, London, April, 1887, pages 25-26, and *The Commune of Paris*, London, W. Reeves, 1895, page 1.

required to function freely would revolt against external interferences and governmental authority by forming themselves into independent, self-governing communes.

The Communes of Paris not only portrayed the necessity of a communalist revolution, it also served to reinforce and indicate the necessity and possibility of a truly urban though distinctively anarchist landscape.

The communes of the post-revolutionary period would not be small and isolated communities or phalansteries, comprising, at the most, of a few thousand people, which were in any case "repugnant" to the majority of humanity. On the contrary, they would rather consist of sizeable, indeed "vast agglomerations", of huge, autonomous and self-sustaining "agro-industrial communes". These communes, Kropotkin hoped, would not remain isolated and detached from each other, but would federate to form "small territories" as the communes of the Great French Revolution had done in the Fête of the Federation. Geographically and economically independent regions would in turn federate to form loosely defined nations. Paralleling this process, "labour" and interest-related "associations" would develop to manage "inter-communal services" and cater for those intellectual and artistic needs that would remain unfulfilled within the individual commune or region.[490]

Although the state is now the predominant organisational force in society, it is also the case that non-governmental organisation remains a significant force in all socieites. Many problems, for example contemporary environmental ones, especially over-exploitation, are often best dealt with through local grass roots initiatives involving the ordinary people that live within or make their living from the areas of

[490]Preface to the 1913 edition of *The Conquest of Bread,* London, Chapman and Hall, 1913.

concern. When needed, these local organisations often come to federate with similar ones nearby or make contact or associate with like-minded groups elsewhere. More generally non-governmental organisations, in both positive and negative capacities, play an increasingly important role in many societies. It is the continual throwing up of such non-governmental grass roots organisations, throughout history, and at the present day, upon which Kropotkin, bases his ideas concerning the possibility of stable, technologically advanced, environmentally balanced and complex societies operating in the absence of the institutions of centralised governmental authority. It is this emphasis on federations of non-territorial communities of interest which represents an especially interesting and modern aspect of Kropotkin's anarchism

The Social Resolution of Conflict

People unfamiliar with anarchist theory and practice, find it implausible that modern society could operate smoothly and peacefully in the absence of the familiar institutions of law and authority. This might well be the case. It is perhaps, with good reason that, countries or regions where these institutions have broken down, through corruption, decay or war that, their state is said to be one of a state of chaos or anarchy. Nonetheless, it is important to remember that, the state, may, more often than not, be brutal, corrupt and the primary cause of catastrophic wars. The 20th century saw no shortage of such regimes. The 21st century will no doubt see many more!

Conflict Resolution in Stateless Societies:

Kropotkin, on the basis of his observations of indigenous communities and traditional village life, as well as his researches concerning the customs and habits of distant peoples of the past and present, concluded that the face-to-face communication and economic interdependency, which typified pre-governmental societies spontaneously, generated mechanisms for controlling anti-social or violent behaviour. Tolerable levels of conflict and anti-social behaviour, rather than being controlled by governmental authority, were maintained by the community, through the "continued action of all"[491] its members. Unlike today, where people rely upon external force and authority or simply call for "fresh laws", the members of these early communities had "themselves to alter what was bad."[492] Self-government and self-administration had been successful in stateless societies because the rule of "everyone for all"[493] had been "carried into the functions of life within the free community".[494] The high levels of complex interpersonal communication and communal interdependence were as effective as the state in controlling anti-social behaviour:

> “Today we live side by side without knowing one another. We come together at meetings on an election day: we listen to the lying or fanciful professions of faith of a candidate and we return home. The state has the care of all questions of public interest; the state alone has the function of seeing that we do not harm the interests of our neighbour...Our neighbour may die of hunger or murder his children—it is no business of ours; it is the business of the policeman. You hardly know one another, nothing unites you, everything tends to alienate you from one another, and finding no better way you ask the state to do all that lies within its power to stop anti-social passions from reaching their highest climax.[495] Private property has led us to an egoistic individualism in all our mutual relations. We know one another only slightly; our points of contact are too rare. But we have seen in history examples of a communal life which is more

[491] Kropotkin, *Anarchism: Its Philosophy and Ideal*, Revolutionary Pamphlets (ed. Baldwin), page 137.
[492] Kropotkin, *Law and Authority,* Revolutionary Pamphlets (ed. Baldwin), page 196.
[493] Kropotkin, *Ethics, Origin and Development*, Tudor Publishing Co., 1947, page 78.
[494] Kropotkin, *Anarchist Communism*, Revolutionary Pamphlets (ed. Baldwin), page 52.
[495] Kropotkin, *Anarchism: Its Philosophy and Ideal*, page 140.

> intimately bound together—the "composite family" in China, the agrarian communes, for example. These people really know one another. By force of circumstances they must aid one another materially and morally."[496]

The idyllic picture of peasant villagers is undoubtedly a myth. There has never been a culture in which members have on every occasion spontaneously behaved co-operatively. All societies, even the most co-operative of them, have to find methods of resolving conflict. Kropotkin argued that in the place of external force and authority, the free community possessed "a thousand other means for preventing anti-social acts".[497] These consisted of an enormous variety of what anthropologists now call "diffuse sanctions". Diffuse sanctions can be applied by any member, and can range from the simple sanctions of approval and disapproval to the more extreme sanctions of excommunication and ostracism, and even, though less commonly, duels, feuds and arm-to-arm combat. Kropotkin had, however, an optimistic view of human nature. He considered that the "authority of public opinion"[498] and the simple sanctions of approval and disapproval provided, for the most part, a sufficient and effective mechanism of control. He claims that our "words and looks", our "ways of speaking, smiling, frowning, getting heated, or keeping cool",[499] and the use of "ridicule",[500] would in the majority of cases prevent anti-social behaviour. Although optimistic, Kropotkin was not naive. He adequately appreciated that more extreme sanctions, such as excommunication and ostracism, would on certain occasions need to be applied in any community.

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[496] Krotpotkin, *Prisons and Influence on Prisoners*, Revolutionary Pamphlets (ed. Baldwin), page 232.

[497] Kropotkin, *Anarchism: Its Philosophy and Ideal*, page 134.

[498] Kropotkin, *Mutual Aid*, London, Heinemann, 1915, popular edition, page 70.

[499] Kropotkin, *Anarchist Morality*, Revolutionary Pamphlets (ed. Baldwin), pages 104 and 101.

[500] Kropotkin, *Ethics, Origin and Development*, page 70.

Although such activities seem fairly trivial in today's society, shaming, ridiculing and gossip are forms of diffuse sanction which have been used in all societies, up to the present, to control what is perceived as deviant behaviour by other members of the social group. These simple sanctions of approval and disapproval, in those areas of life where people meet each other on a regular basis upon a face-to-face level, such as the school yard, office, pub or sports club, still remain an effective means of getting people to obey socially acceptable norms and standards. Smiling, frowning and other gestures of approval and disapproval, as well as more socially organised sanctions of "shaming" by means of ridicule and taunting, were cruelly effective in smaller, face-to-face communities of the past. In his *Ethics*, Kropotkin notes that in such societies women, and even the children of the village or band, could sing rude, humorous or malicious songs within earshot of the offender:

> "Each family is divided from the others by a curtain made of hides. These corridor-like dwellings are sometimes made in the shape of a cross in the centre of which is located the hearth. On long winter nights the women sing songs in which they not infrequently ridicule those who are in some way guilty of transgressing the customs of good behaviour."[501]

In stateless communities, economic activities tended to be non-specialised and non-compartmentalised. Although different duties were often performed by men, women or children in many of these societies, all members were equally capable of carrying out a wide variety of vital economic tasks. A community economy consists of complex webs of co-operation and reciprocation on which the well-being of the individual as well as the community as a whole depended. The extreme economic interdependency both within and between tribal groups or communities meant that the threatened withdrawal of vital economic services was one of the most effective

[501] Kropotkin, *Ethics, Origin and Development,* page 70.

means of social control. The suspension of economic co-operation often meant hunger and extreme hardship. It was a very real threat to the well-being of the particular individual who was thus forced to contribute towards the economy of the group. The following passage from Kropotkin's anarchist utopia, *The Conquest of Bread*, is illustrative of how he envisaged the sanctions of ostracism and excommunication might operate within a future social-anarchism:

> "Twelve or fifteen hundred hours of work a year, in one of the groups producing food, clothes, or houses, or employed in public sanitation, transport, and so on, is all we ask of you. For this amount of work we guarantee to you the free use of all that these groups produce. But if not, one of the thousands of groups of our federation, will receive you, whatever be their motive; if you are absolutely incapable of producing anything useful, or if you refuse to do it, then live like an isolated man or like an invalid. If we are rich enough to give you the necessaries of life we shall be delighted to give them to you. You are a man, and you have the right to live. But as you wish to live under special conditions, and leave the ranks, it is more than probable that you will suffer for it in your daily relations with other citizens. You will be looked upon as a ghost of bourgeois society, unless some friends of yours, discovering you to be a talent, kindly free you from all moral obligation towards society by doing all the necessary work for you. And finally, if it does not please you, go and look for other conditions elsewhere in the wide world, or else seek adherents and organise them on novel principles. We prefer our own. This is what could be done in a communal society in order to turn away sluggards if they became too numerous."[502]

In another passage, this time from his pamphlet *Anarchist Communism*, Kropotkin, taking the example of the (voluntary) British Life Association, claims that where social-cooperative practices have been entered into freely, forceful coercion and formal punishment will have become unnecessary:

[502] Kropotkin, *The Conquest of Bread*, popular edition, 1913, pages 206-7.

> "We do not see the necessity of force for enforcing agreements freely entered upon. We never heard of a penalty imposed on a man who belonged to the crew of a lifeboat and at a given moment preferred to abandon the association. All that his comrades would do with him, if he were guilty of a gross neglect, would probably be to refuse to have anything further to do with him."[503]

In Stateless societies, the intervention of arbiters, facilitators and go-betweens was also a very effective means of resolving disputes between individuals and groups. People who were respected in the community or who were otherwise good at listening to opposing points of view often intervened on behalf of the community. Although in some societies the role of the arbiter or facilitator was to some extent formalised, more often than not a neutral relative or friend of the disputing parties would take on the role on behalf of the community as the need arose. Kropotkin did not deny that serious conflict would at times occur, both within and between communities. He did not, however, regard this as unhealthy, nor consider the possibility of conflict as constituting a serious problem. In his article *Organised Vengeance Called Justice*, Kropotkin claims that such contests would be few and infrequent, being in the vast majority of cases easily settled by arbitrators:

> "Everyone will see that arbitration, arbiters being chosen by the contending parties, will be sufficient in the very great majority of cases to quell arising disputes. Everyone will admit that the policy of non-interference now so greatly favoured is a bad habit acquired since the state found it convenient to assume the duty of keeping order. Active intervention of friends, neighbours, passers-by, would prevent a large proportion of conflicts. Let it be everybody's duty to assist the weak, to interfere between fighting people, and police will no longer be required at all."[504]

[503] Kropotkin, *Anarchist Communism*, pages 69-70.
[504] Kropotkin, *Organised Vengeance Called Justice*, Freedom, London, October 1901.

The use of witchcraft and magic to ensure compliance through instilling fear in others was also a common means of controlling other people's behaviour. In more aggressive societies, the threat of (rather than actual) violence served much the same function. Feuding, revenge and combat, although far from universal, was a common feature in the life of many communities. Whilst some societies were extremely violent others managed to resolve all their conflicts through talking without ever feeling the least need of resorting to violent revenge and fighting. A contemporary legal anthropologist, Simon Roberts, in his short but stimulating study, *Order and Dispute: An Introduction to Legal Anthropology*, concludes that of all the sanctions and control mechanisms that were available to stateless societies, the withholding of essential forms of economic co-operation and social ostracism were, perhaps, the most common and most feared:

> "The stress which much western legal theory has placed upon organised force and the role of enforcement agencies can...lead to misunderstandings so far as many of these societies are concerned. In stateless societies, there may well be no-one recognised as competent to hand down a decision to disputants from a third party standpoint, let alone enforce that decision once it has been made. Thus, third parties are typically limited to acting as go-betweens, transmitting messages from one disputant to another, or as mediators, actively coaxing the parties towards a settlement, but still without the power to resolve the matter by decision...Most important, perhaps, is the fact that even where judicial institutions are found they do not always enjoy the unchallenged pre-eminence in the business of dispute settlement which our courts claim and manage to exercise. Fighting and other forms of self-help, resort to supernatural agencies, the use of shaming and ridicule or the unilateral withdrawal of essential forms of co-operation may all constitute equally approved and effective means of handling conflict. In many stateless communities the most dreaded and effective

> sanction in the face of sustained anti-social behavior is the withdrawal by other members of the society from social contact and the withholding of essential forms of economic co-operation: quite the reverse of what we commonly understand as coercive force."[505]

The maintenance of tolerable levels of conflict and the control of anti-social acts in stateless societies were maintained by the community itself, through the continued action of all its members. Unlike today, where people have come to rely upon external force and authority or simply call for "fresh laws", the members of these early communities had themselves to alter what was bad. Self-government, self-administration and the rule of everyone for all had necessarily been an integral function and prominent feature of life within the free community.

Medieval forms of Community Based Social-Environmental Organisation for the Distribution and Conservation of Resources and the Prevention and Resolution of Conflicts over them:

Egalitarian, non-governmental or community-based forms of social control were not, however, confined to hunter-gatherer, herding and horticultural societies. In Europe, the egalitarian rule of everyone for all was a prominent feature of social life wherever villages, towns or cities grew independently or gained some degree of autonomy from the monarchal state order. In Russia, right up until their brutal collectivisation by the state-communist party at the beginning of the 20th century, all the villagers of the commune, despite paying their tithes to the noblemen, still met annually at the *mir* to divide up the land and workload for the following year. These traditions were remnants from a time before the rise of tsardom when the village was a free-community of farmers and artisans who made their own laws and divided their resources and produce according to the wishes of all the people of the village.

[505] Roberts, S., *Order and Dispute*, Harmondsorth, Penguin, 1979, pages 26-7 passim.

In Switzerland, where the monarchal system never established any firm hold, such traditions survive in some of the smaller cantons where varying degrees of direct democracy still prevail. Kropotkin, in his *Words of a Rebel,* uses the example of the Swiss custom of "The Field of May". In May, the citizens gather in a field on the edge of town and vote for their own laws on the spot whilst appointing a council to see that the people's will is carried out. The early town meetings in the United States of America were, likewise, an attempt by the people to resurrect free communal and direct self-government by the people and for the people.

As the United Nations is presently meeting to discuss the global 'water crisis', it is worth pausing to note how in the past customs and traditions had ensured the preservation of fundamental environmental resources. For example, to this very day, in the Valencia orange growing region of Spain, which although fertile is naturally quite arid, the control and distribution of the precious water, is overseen by a non-governmental water tribunal. This was founded in 1238 by the Moors. The orange growers sharing each individual water channel vote in their own representative of the tribunal. Although they are not magistrates, if an individual does not pay their fines (for such oversights as not keeping the channels clear of weeds and debris) or in other ways disobey the tribunal, the farmer simply won't receive the water normally due. However, instances of this nature are rare, on account that it is embarrassing, and considered shameful to be summoned before the tribunal. Thus the water is collectively owned and distributed sustainably by the people who depend upon it for their living. [506]

[506] Information upon the Water Tribunal comes from my notes taken while watching an edition of a French-made documentary series 'Global Village' broadcast and subtitled by Special Broadcasting Services, Australia.

The need to conserve and manage water more effectively is gradually becoming an important political and environmental issue in many countries. In Australia the landcare movement, once consisting of independent and unconnected grouplets are now beginning to link up around catchments to form watershed federations, in order to manage water courses in an integrated, grass-roots way. Those who are acquainted with the environmental movement will appreciate that this kind of voluntary, grass-roots, non-governmental approach to environmental regulation and protection is typical of many green federations, such as seed networks, which facilitate the free exchange of seed varieties. Such networks may provide a vital role in protecting agro-biodiversity in the face of the capitalist patenting of germplasm, deforestation and the decline of traditional rural economies/technologies.

Resolution of Economic Conflict in the Medieval City:

Before the Medieval city-commune was absorbed into the monarchal state it had achieved a high degree of self-government. This is particularly true with regard to its internal economy. Within the city, the members of each trade guild effectively managed their conflicts by means of arbitration, internal self-administration by the workers in each trade providing a way of resolving economic disputes within and between different trades for the overall health and stability of the city. Economic stability led to social stability, and there is no doubt that the great architectural and industrial developments that occurred in the era of the free medieval city were, in a large part, due to direct self-government by the workers of their trade within the wider context of a genuine and well-rounded human community. Kropotkin, in a remarkable (and much neglected article) entitled *The Development of Trades Unionism,* observed how workers' self-organisation and control, when structured within the context of municipal self-government, had been successful within the medieval cities; that the modern trades union and syndicalist movements, if they were truly to realise their democratic ideal, had much to gain from the careful study of the craft-guilds of the free medieval city-commune:

> "For many years in the medieval towns the workers of all nations were united in unions and very often it is said that the guilds of old have given origin to the trade unions of today. Perhaps it is true, but the modern Trade unions are absolutely different from the old guilds; they cover but a very small part of the field covered by the unions of old. The workers of the guild considered themselves as the masters of the industry—not as men who were being hired to do the work without any interest in the management of the concern. They did not consider themselves as outsiders to industry: they considered rather, the capitalists, as the outside and useless element. They used to buy all raw material and to sell the produce. They managed the industry entirely; and the cities were nothing but the unions of these unions, the *amitas* between these unions. When they had to export something, they did not leave it to someone going to find new markets in Africa, nor in China. It was the city which carried on the export, it was the city which was considered the first, the great consumer. Moreover, the guild was supreme in its own concerns; it was autonomous. If any dispute arose between two workers of the same guild, it was to the arbiters (or judges, if you like), nominated by the guild if it had to be referred. If any dispute arose between two workers of different unions, it was referred to the person elected by these two unions, who if they disagreed could call in the nominee of a third to decide."[507]

When disputes between different trades or guilds could not be settled by internal arbitration it was ultimately "The City" that decided the issue for them.

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[507] Kropotkin *The Development of Trades Unionism* , Freedom, London, March 1898, page 9.

Just as Kropotkin observed how workers could effectively resolve economic and industrial disputes, he likewise saw the social development of "family tribunals" (so long as they remained apart from the institutions of state) as an effective method of controlling domestic disputes. Although Kropotkin did not advocate a return to small scale and isolated or tribal communities, the "extended neighbourhood" conception of the city-commune, upon which his social-anarchism was based, is certainly consistent with quite formal methods of community self-control:

> “...if men lived in closer contact with one another, and had continually to come into contact on those public affairs which now are vested in the few; and if, in consequence of a closer contact, we were brought to take as lively an interest in our neighbours' difficulties and pains as we formerly took in those of our kinsfolk—then we should not resort to policemen and judges, to prisons and executions. Anti-social deeds would be nipped in the bud, not punished. The few contests which would arise would be easily settled by arbitrators; and no more force would be necessary to impose their decisions than is required now for enforcing the decisions of the family tribunals of China.”[508]

The Origin and Development of Law:

Kropotkin thought that the customs and habits which had developed in stateless societies fell into many classes, but when analysing he divided them into just two: those which benefit the wellbeing of the community as a whole, and without which social life would become impossible, and others that have tended to support the activities of more powerful individuals and cliques. Those customs which may be deemed "useful to society" are many and numerous, the most important of them being: those designed to control conflict or promote group solidarity; traditional mechanisms to gather, distribute and exchange vital economic resources; ecological

[508] Kropotkin *Anarchist Communism,* pages 72-3.

customs that ensure the maintenance of good hunting, farming or pasture; marriage and other sexual customs and taboos that promoted stable sexual relations; as well as those basic moral concepts that have been found in all known cultures against theft,violence or malice against any member of one's kin. These customs, usages and habits are not established by law, either human or divine, but spring forth naturally from the social life of our species. The rudiments of this can be observed in the habits of the social animals. The play-fighting amongst pups which never seems to harm any one of them; a polite yawn or nod from a passing cat; the habitual sharing out of the kill or the highly ritualised dancing of honey bees, clearly show that civilised and ritualised behaviour within the lifestyles of the social animals may be as elaborate and decorative as that of some of our own.

The desire to dominate, to obtain nourishment without having worked for it or to look after one's own interest is as strong within our species as the desire for egalitarian co-operation with one's fellows. The priest/ess, head man and elders, through religious trickery, brute strength and intellectual superiority, built upon the superstitious nature of early humanity and the predisposition to routine, and succeeded in developing a parallel system of customs that were designed to benefit the crafty priest over the people, the strong man over the weaker men and women, the old over the young or the few over the many:

> “Side by side with customs necessary to the life of societies and the preservation of the race, other desires, other passions, and therefore other habits and customs are evolved in human association. The desire to dominate others and impose one's will upon them; the desire to seize upon the products of the labour of a neighbouring tribe; the desire to surround oneself with comforts without producing anything, while slaves provide their master with the means of procuring every sort of pleasure and luxury—these selfish personal desires give

> rise to another current of habits and customs...The sprit of routine...has in all times been the mainstay of oppression. In primitive human societies it was cleverly turned to account by priests and military chiefs. They perpetuated customs useful only to themselves, and succeeded in imposing them on the whole tribe."[509]

The great warrior, spiteful witch or malevolent elder would in due course die and, in the absence of any formal structure perpetuating organised dominance, their influence simply died with them—at best their offspring gaining some prestige for having been born from such a feared/respected person in the community. Nonetheless, in those societies, where religious, male, or ageist authority was tolerated, the spirit of routine and the desire to lead a lazy, trouble-free life at the expense of others led to the development of hierarchies that became crystallised in the everyday customs of the people. As society grew larger and organic communities disintegrated these primitive theocracies and gerontocracies slowly came to acquire more and more of the land or resources and begin to individually assume responsibility for many questions which had formerly been decided by the whole community. Humanity became increasingly divided into two hostile camps: a minority who wanted to maintain their wealth, privilege, power and authority, and the majority who only wanted to escape from religious, cultural, military and economic domination by that minority. Unable to maintain their privileges by force of number or solely by means of their military, the conqueror, king and high priest sought to give permanence to their positions of dominance through the imposition of Law. The Law was, of course, in these times little more than another name for the collection of customs that had developed amongst the people—and herein lies its success as a means of imposing domination. For, as we have seen, within the

[509] Kropotkin, *Law and Authority*, pages 203-4.

customs of the people lay a precious kernel of social customs, taboos and practices that benefited all the people. When the king's men apprehended the cattle rustler or the church upheld the ancient religious traditions this was regarded as something right and proper to the masses of people, who comprehended the benefits of peace and justice and were culturally predisposed to venerate traditional values. However, along with those customs, taboos and practices which are useful to humanity and have been found in all societies, both animal and human, there lies a second set of customs that maintains the special privileges of the chosen élite. By carefully mingling those customs which are useful to society with those which benefited only a very few, and placing them all under the general concept of the Law, which they deemed divinely sacrosanct and unchallengeable, the war-lords, brigands and holy men established themselves as the unquestioned rulers of the people:

> "...As society became more and more divided into two hostile classes, one seeking to establish its domination, the other struggling to escape, the strife began. Now the conqueror was in a hurry to secure the results of his actions in permanent form, he tried to place them beyond question, to make them holy and venerable by every means in his power. Law made its appearance under the sanction of the priest, and the warrior's club was placed at its service. Its office was to render immutable such customs as were to the advantage of the dominant minority. Military authority undertook to ensure obedience. This new function was a fresh guarantee to the power of the warrior; now he had not only mere brute force at his service; he was the defender of the law. If law, however, presented nothing but a collection of prescriptions serviceable to rulers, it would find some difficulty in insuring acceptance and obedience. Well, the legislators confounded in one code the two currents of custom: the maxims which represent principles of morality and social union wrought out as a result of life in common, and the mandates which are meant to ensure external existence to inequality.

Customs, absolutely essential to the very being of society, are, in the code, cleverly intermingled with usages imposed by the ruling caste, and both claim equal respect from the crowd. "Do not kill", says the code, and hastens to add, "And pay tithes to the priest". "Do not steal", says the code, and immediately after, "He who refuses to pay taxes, shall have his hand struck off". Such was law; and it has maintained its twofold character to this day. Its origin is the desire of the ruling class to give permanence to customs imposed by themselves for their own advantage. Its character is the skilful commingling of customs useful to society, customs which have no need of law to insure respect, with other customs useful only to rulers, injurious to the masses of the people, and maintained only by the fear of punishment."[510]

The Double-edged Nature of Law in the Modern State:

The French Revolution, before it fell prey to bourgeois land speculation and centralism, was, Kropotkin argues, essentially an attempt by the peasants to claim back the 30,000 communes of France. That the true vision of the French Revolution was a society of federated and autonomous city-communes is evidenced by the communal uprising in Paris, as well as in many other major cities and towns, nearly a century later in 1871.

After the collapse of feudalism the newly emerging capitalist classes inevitably came into conflict with the peasantry. The peasants demanded that the village lands, which had been liberated from the church and crown, should be returned to the village and not "sold" to capitalist property speculators. However, wearied by the years of famine, uncertainty and ruin, which all revolutions have brought in their wake, the peasants easily gave in to any system that might ensure enough peace for just one successful harvest. The notion of "equality before the law" for both rich and for poor seemed to offer infinitely more hope of justice than that

[510] Kropotkin, *Law and Authority*, pages 205-6.

endured by the divine right of kings and the arbitrary rule of the squirearchy. In Kropotkin's words:

> “This new worship has been established with especial success since the rise to supreme power of the middle class—since the great French Revolution. Under the ancient regime, men spoke little of laws; unless, indeed, it were, with Montesquieu, Rousseau and Voltaire, to oppose them to royal caprice. Obedience to the good pleasure of the king and his lackeys was compulsory on pain of hanging or imprisonment. But during and after the revolutions, when the lawyers rose to power, they did their best to strengthen the principle upon which their ascendancy depended. The middle class at once accepted it as a dyke to dam up the popular torrent. The priestly crew hastened to sanctify it, to save their bark from foundering amid the breakers. Finally the people received it as an improvement upon the arbitrary authority and violence. To understand this, we must transport ourselves in imagination into the eighteenth century. Our hearts must have ached at the story of the atrocities committed by the all powerful nobles of that time upon the men and women of the people before we can understand what must have been the magic influence upon the peasant's mind of the words "Equality before the law, obedience to the law without distinction of birth or fortune". He who until then had been treated more cruelly than a beast, he who had never had any rights, he who had never attained justice against the most revolting actions on the part of a noble, unless in revenge had killed him and was hanged—he saw himself recognised by this maxim, at least in theory, at least with regard to his personal rights, as equal of his lord.”[511]

Bourgeois or state-capitalist law thus kept its double-edged character. Along with statutes, codes and orders to keep the peace came laws whose only purpose was to uphold and enlarge the fortunes of the manufacturer or private landowner. One's right to own a sumptuous mansion or a hotel chain was enshrined in law; the right to

[511] Kropotkin, *Law and Authority*, pages 198-9.

a roof over one's head was not! The right to choose one's own master was heralded as the pinnacle of freedom whilst the demand for the full remuneration for one's labour was not. The majority of all laws, claimed Kropotkin, were for the protection of property, capital or government.

Causes and Cures of Crime:

The causes of crime, Kropotkin, contended could be divided into three classes: physical, physiological and social. Bad harvests, miserable weather and a host of other quite natural and inescapable physical events obviously affect the temperament of people: "When the weather is fine and the harvest good, and when the villagers feel at their ease, certainly they will be less likely to end their petty squabbles with knife thrusts".[512] The second cause of crime was that of ill-health and disease. But although such physiological disorders seemed unavoidable, social or external factors often induced their expression or greatly worsened their effects. Thus, apart from famine and physiological disintegration of the mind, Kropotkin thought that *social* or *environmental* causes represented the single most important factors. The decline of traditional community coupled with the rise of capitalistic-individualism was to a large extent responsible for the growth of a criminal class:

> “Speak to an imprisoned man or to some great swindler. He will say: "The little swindlers are here but the big ones are free and enjoy public respect". What can you answer, knowing the existence of great financial companies expressly designed to take the last pennies of the savings of the poor, with the founders retiring in time to make good legal hauls out of these small fortunes? We all know these great stock issuing companies with their lying circulars and their huge swindles. What can we answer the prisoner except that he is right? Or this man, imprisoned for robbing a till, will tell you: "I simply wasn't clever enough;

[512] Kropotkin, *Prisons and Influence on Prisoners*, page 229.

that's all." And what can you answer, knowing what goes on in important places, and how, following terrible scandals, the verdict "not guilty" is handed down to these great robbers?...Year in and year out thousands of children grow up in the midst of the moral and material filth of our great cities in the midst of a population demoralised by hand to mouth living. These children do not know a real home. Their home is a wretched lodging today, the streets tomorrow. They grow up without any decent outlets for their young energies. When we see the child population of large cities grow up in this fashion, we can only be astonished that so few of them become highwaymen and murderers...And at the other end of the ladder, what does the child growing up on the streets see? Luxury, stupid and insensate, smart shops, reading matter devoted to exhibiting wealth, a money-worshiping cult developing a thirst for riches, a passion for living at the expense of others. The watchword is: "Get rich. Destroy everything that stands in your way, and do it by any means save those that will land you in jail". Manual labor is despised to a point where our ruling classes prefer to indulge in gymnastics rather than handle a spade or a saw...Society itself daily creates these people incapable of leading a life of honest labor, and filled with anti-social desires...*Man is the result of the environment in which he grows up and spends his life. If he is accustomed to work from childhood, to being considered as a part of society as a whole, to understanding that he cannot injure anyone without finally feeling the effects himself, then there will be found few cases of violation of moral laws*...Two-thirds of the acts condemned as crimes today are acts against property. They will disappear along with private property. As for acts of violence against people, they already decrease in proportion to the growth of the social sense and they will disappear *when we attack the causes instead of the effects*...Family life, based on the original community, has disappeared. A new family, based on community of aspirations will take its place. In this family people will be obliged to know one another, to aid one another and to lean on one another for moral support on every occasion."[513]

Thus, Kropotkin argues, the re-emergence of the natural community through the destruction of state-capitalism would have a significant effect on reducing the incidence of serious crime and violence within society.

Kropotkin, who had in his youth undertaken an extensive survey of conditions in Russian prisons, was later to spend many years in both Russian and French prisons. Kropotkin had committed no crime other than to have the courage to stand up to a ruthless dictator and herald the cause of liberty and freedom. In consequence of this he continued to take a practical interest in prison issues. Kropotkin, was a tireless prison activist. He penned countless letters and articles for establishment newspapers, such as *The Times* of London, concerning the (still dreadful) conditions of Russian prisons. In 1908 during his English exile he devoted a considerable amount of time exposing the growing brutality of the Russian prison system. His account of the "White Terror" eventually reached the size of a small book which somewhat ironically came to be published as a British Parliamentary Committee Report in 1909. It is a testament to Kropotkin that a British parliament accepted that a convicted anarchist could also be an expert on prison issues. His central idea that crime was more often or not the result of a poor social environment is a very modern idea, that remains sharply at odds with contemporary approaches to crime, such as can be seen in the "three strikes and your out" policy in America or "mandatory sentencing" in Western Australia and the Northern Territory.

Kropotkin observed that the prison environment not only failed to prevent crime but actively nurtured it. The prison, rather than reforming the criminal, tended

[513]Kropotkin, *Prisons and Influence on Prisoners*, pages 222-3; 231-4 passim; my emphasis.

rather to act as a school of crime. The problem of repeat offenders proves this fact beyond doubt:

> “Once a man has been in prison, he will return. It is inevitable, and statistics prove it. Another significant angle is that the offence for which a man returns to prison is always more serious than his first. If before, it was petty thieving, he returns now for some daring burglary, if he was imprisoned for the first time for some act of violence, often he will return as a murderer.”[514]

Apart from learning the "tricks of the trade" from other criminals, Kropotkin thought that the primary reason for this failure was that the prisons "killed all the qualities in a man which make him best adapted to community life".[515] The effects of cutting off social contacts and the petty nature of the prison regime made the prisoner progressively more unsuitable for his re-integration into community life. Of all the drawbacks of a system based on isolation, deprivation and systematic cruelty, his major criticism was that it was specifically designed to destroy the willpower and self-discipline of the individual. The idea that prisons could be reformed was, Kropotkin thought, a ridiculous proposition. Their institutional, authoritarian and hierarchical nature meant that even if the best of people were chosen as guards they would nonetheless become corrupted and degraded. In placing people in near absolute control of other people it was only a matter of time before the relationship between prisoners and guards degenerated into pettiness and tyranny.

Most importantly, the legal and penal systems sought to cure "social diseases" or "crime" by treating its symptoms rather than trying to "prevent" crime from developing in the first place.[516]

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[514] Kropotkin, *Prisons and Influence on Prisoners,* Revolutionary Pamphlets (ed. Baldwin), pages 210-!1.

[515] Ibid, page 221.

[516] Kropotkin, *Prisons and Influence on Prisoners*, page 228.

Non-Governmental Organisation and Social Order in the Modern World:

As society changes new needs are continually generated. Although capital and state, in our present society, provides for some of these needs, the profit motive and bureaucracy are not appropriate for many of the services upon which civil life depends. Voluntary blood donation is better than a profit orientated service as people with serious blood born diseases may be tempted out of desperation to donate blood for need of money. Top-down governmental approaches to eliminating rural poverty or delivering aid have frequently failed in their purpose. Even the World Bank is bypassing national governments and delivering benefits to the people through non-government organisations. Increasingly people, as well as governments, have come to rely upon a wide variety of non-government organizations for such vital tasks. Indeed, the Red Cross, which Kropotkin uses as one of his examples, has performed such a role for considerably longer. Many institutions which get their funding from government, for example, family planning clinics in the UK, were first started by pioneering women if the field of female (sexual) health and contraception. In other cases, such as the British Lifeboat Association, also cited by Kropotkin, human self-organisation has done the job so well that there has never been felt any need for governmental interference and capitalist finance. Recently capital, in the form of Kellogg's, the breakfast cereal company has become a major sponsor of the Australian Surf Life Savers, and we have to suffer their logo, seemingly upon everything associated with the once independent, though vital emergency service. In other cases, emergency services are often financed by government but organised and run by voluntary labour. In the 19th century there was a large fire in Chile's capital Santiago and unfortunately there was no established fire service. Afterwards the people of the city decided to establish one. The various immigrant communities, the

French, German, Spanish and so one, set up their own brigades, (presumably because they were predominant in different sections of the city) and maintain these ethnic affinities to the present day. Unlike the British Lifeboat Association, however, the plant is supplied to the fire fighters by the government. Their Labour remains, however, entirely voluntary, the only payment, civic admiration and their pride which they receive from the people they serve.[517]

Kropotkin asks us, upon the basis of similar examples of mutual-aid organizations, to imagine a society which has successfully managed to self-govern itself by means of them. He asks us to imagine a new society where urban land and housing is administrated by community housing associations. In the countryside, the forests, parries and watersheds would be managed collectively by the people through accountable, local bodies and federations of them. Articles of manufacture are conceived as being delivered by worker's co-operatives and syndicates. Food and energy was to be produced in each suburb from micro-hydro, wind, solar power and urban wastes. Not only would community/work based mutual-aid organization create a drastic reduction in crime and poverty, but would, Kropotkin claims, allow for the development of a new integrated communal-urban society where the institutions of law and authority would no longer be required.

Kropotkin is a major figure in late 19th century criminolgy and penalism. In addition to his considerable work as a prison activist, his central insights, which are that, crime begins when community ceases and, the observation that empirical evidence revealed that the reform of criminal behavior could not be achieved by means of prisons are, both today, generally accepted as true. The new-right approach

[517] Information upon Chile's fire brigades comes from my notes taken while watching an edition of the French made documentary series 'Global Village' broadcast and subtitled by Special Broadcasting Services, Australia.

to the use of prisons, doesn’t pretend for a moment that they are trying to reform the criminal in any way. It is a simple ‘keeping the criminals of the streets’ approach to crime. Even the supporters of the ‘tough on crime’, ‘tough on drugs’ approach of recent US administrations, don’t deny that it is the breakdown of family and community values that is often responsible for much of the crime that afflicts their society. This is implicitly acknowledged by virtue of the fact that these same conservative forces continuously call for the support of ‘family’ values, albeit, conservative ones. Thus despite believing in innate criminality, the idea that some people are simply bad and are born that way, other significant elements in conservative ideology contradict such ideas.

Kropotkin’s ideas are very modern and he was really one of the first people to examine the causes and control of crime from a community viewpoint. Nonetheless, the idea of a society without law enforcement is almost incomprehensible to people not associated with anarchist ideology. The desire to dominate or free load is as strong among mammals as that of mutual aid, and these tendencies are observable in differing degrees in our nearest primate relatives. Kropotkin also never discusses such areas as sexual crime, which are not so easily explained away by socialist type arguments.

Although Kropotkin’s anarchism may be utopian, it is a fact that community structure and non-governmental, grass-roots organisation is necessary to the stability of society. When ever a social need arises a mutual-aid organisation spontaneously arises to meet it. Although government may intervene later social initiative comes from below. Whether or not anarchy is possible or not, Kropotkin’s critique of law and authority, whether in preventing crime or preserving and enhancing the environment, is useful in that it highlights the limited, and often dangerous, results of relying upon government to deal with social conflicts, and resolve or repair the very many social and environmental problems that concern us at the present day.

Kropotkin's Social-Environmental Vision

Light Industrial Villages Combined with Intensive Horticulture and Sustainable Agriculture:

Kropotkin, took a profound interest in how it might be possible to improve traditional rural life. The peasant commune, once released from its feudal yoke and equipped with appropriately scaled technology and improved industrial and agricultural techniques was to become a vital force in the post-revolutionary construction of anarchist society. Indeed, Kropotkin, imbued with the populist idealism of Sofia Perovskaya and Andrei Zhelyabov, almost instinctively took the side of the peasant. The early English Marxist, and founder of the Social Democratic League, Henry Mayers Hyndman, for example, thought it comical that Kropotkin, in a political argument, earnestly and steadfastly maintained that the wishes of a small peasant community *not* to have a railway or road connecting two large cities pass through their village could on no account be overturned.[518] Kropotkin's vision was that of a regional town, city and country balance where the smaller country villages and towns, although independent, both supported and were in turn supported in a harmonious way with the major cities and towns of the region.

Kropotkin was extremely interested in recent technological developments and placed an enormous amount of faith in technology's ability to overcome many of the problems of social existence which still unfortunately haunt us. Indeed, Kropotkin's reflections upon the future uses of resources like electricity deeply impressed many of his 19th century contemporaries. The advancement of technology would, he

[518] Hymnman, H.M., *The Record of an Adventurous Life*, London, Macmillan, 1911, pages 260-7.

rightly claimed, soon allow even the smallest village to be supplied with electricity (through decentralised steam generators or micro-hydro) and, thereby, benefit from the improved industrial and agricultural methods that science and technology had recently begun to develop. Electricity was first to be provided by appropriately scaled steam generators and, eventually, through the utilisation of local, renewable, or alternative energy sources, such as wind, hydro or solar power.[519]

Thus Kropotkin enthusiastically welcomed technological innovation arguing that in a non-centralised communal society industry would no longer be centred in large urban connurbations. The idea was to fully utilise the benefits of technological progress by re-scaling industry to meet the requirements of localism, whilst integrating it with organic horticulture and sustainable agriculture. The ultimate aim being the diversification and dissipation of industry, ideally resulting in communal, regional and national self-sufficiency in both industry and agriculture. Anarchism's goal was, Kropotkin claimed, to have "the greatest possible variety of industries gathered in each country, in each separate region, side by side with agriculture."[520]

It is perhaps the Israeli Kibbutz that most closely approximates to Kropotkin's vision of post-revolutionary *village* life. A very large number of working class Jews (then stateless) were attracted to anarchism and communal socialism during the late 19th and early 20th centuries. The kibbutz movement began, in 1909, in order to create communal settlements on lands, which later became incorporated into the modern state of Israel. Kibbutz*ism* was seen by many as a method of

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[519] *The Conquest of Bread*, 1913 edn., pages 100, 266, 294. Kropotkin also explored the recent developments in solar wind and water power in his *Recent Science* articles of August 1898, The Nineteenth Century pages 1898, pages 271-280.

[520] *Fields, Factories and Workshops*, op.cit., page 22.

achieving a socialist society based upon the self-governing commune with inter-communal trade being regulated by a market economy.

A kibbutz is an agricultural and light-industrial settlement that is collectively owned by its members. In theory, members are not paid wages and children sleep in communal dormitories up until the age of 18. Kropotkin did not consider it a good idea to abandon the family structures. However these extreme communist practices were abandoned after one generation.

Although there are many points of difference between kibbutzism and Kropotkin's anarchism communism, most importantly perhaps, their integration into a market economy and the break-up of the traditional family/household unit, there are significant similarities. The Kibbutzniks introduction of small, light-industrial workshops within their settlements, and their integration with technologically advanced and intensive horticulture combined with sustainable agriculture, was exactly the sort of modern communal village/small town life which Kropotkin envisaged. The kibbutz movement showed how Kropotkin's *rural* vision is certainly able to work quite well in practice and is not as utopian as is often supposed. Kibbutz have worked, socially, economically and agriculturally, producing abundant crops (in often very arid or rugged conditions) and manufactured items.

The rise of urbanism and lack of government support has led to a decline in Kibbutzism in Israel. Whether kibbutzniks will abandon their abandon communal beliefs and practices and the kibbutz turn into normal small towns or villages, only time will tell, but this was certainly the fate of many religious pioneering agricultural communities in the USA. Indeed, this has been fate of all 'successful' community experiments of the past.

Although it will soon be the case that the majority of the worlds population will live in large cities, a little under a half, predominantly the most impoverished, still live in traditional villages. Rather than communal-experimentalists (which we will explore in detail below) it was the peasants, most of all, that Kropotkin, from a young age, most wanted to help. The introduction of sustainable agriculture, intensive organic horticulture and modern, and appropriately-scaled, industry and technology powered by local, renewable energy resources **is exactly what is still needed** in the impoverished and neglected villages of Africa, Asia and South America. Needed, in order, to support rural life and put a halt to the constant drift of people to the ever-growing cities. Cities, where these rural migrants usually live a squalid existence, squatting in makeshift shacks in disease-infested shanty towns. Kropotkin’s vision of co-operative and modern village life, for compelling social and environmental reasons, remains as relevant today as it did a century ago.

Intensive Horticulture (Garden Culture) Combined with Sustainable Agriculture (Field Culture):

Anticipating the late 20th century's preoccupation with the environment and renewed interest in ecological or organic land practices, Kropotkin rejected "[American] extensive" farming methods which merely served to exploit and exhaust the soil in the interests of short-term gain. A concern with the conservation or scarcity of natural agricultural resources, combined with a belief that what damages them is wrong, is a thoroughly modern viewpoint.

Instead of extensive, inefficient and environmentally damaging farming methods, Kropotkin, like many environmentalists today, advocated organic kitchen and market garden culture (horticulture) in and around village settlements along side traditional mixed field culture (agriculture). Additionally, he believed though, that there was considerable room for reform and inventiveness in agriculture, involving a more organic or integrated approach, that involved working with, rather than against nature.

He rejected individual ‘homestead’, or ‘estate’ farming, in favour of a co-operative, and more labour intensive, approach to agriculture that involved utilising micro-climates and natural features of the land “with all its varieties of slopes, aspects, watering, and so on, so as to have from it the largest amount of produce with the least waste of labour.”[521] Thus, instead of turning a very large area over to wheat or stock, less fertile slopes should be given over to trees. In areas which received less frost, orchards and glass houses were to be included in order to gain the maximum advantages of local micro-climates. In order to maximise production, it is suggested that “mixed” tree-plantings should imitate “the natural grouping of trees of a forest”.[522] Such systems are nowadays known as forest gardens where through taking advantage of various micro-niches in natural forest cover (canopy, lower canopy, shrub, ground cover) with a spectrum of desirable species it is possible to gain many different crops or useful products from the same area.

With more traditional field crops, although Kropotkin thought that it was a good idea to take advantage of modern chemical fertilisers, it was only advisable to “supply it with fertilisers (chiefly nitrogen) at those periods of its growth when it most wants them.”[523] Rather than applying fertiliser at the time of sowing the seed, as has been practised for most of the 20th century, farmers are, only now, learning to apply fertiliser later, when the plant are actually able to take it up, in an effort to stop pollution of rivers and ground water by run-off. This not only reduces pollution but

[521] Kropotkin, *What Man Can Obtain From The Land*, Co-operative Wholesale Societies Annual for 1897, Manchester and Glasgow 1897, page 394

[522] Kropotkin, Experimental Farms, Nineteenth Century, November 1897, page 817

[523] Kropotkin, *What Man Can Obtain From The Land*, page 370.

much costly fertiliser as well. Kropotkin, was however, far more interested in organic systems that utilised natural mutualist or symbiotic relationships. For example, he calls for the planting of clover underneath traditional grain crops in order to provide nitrogen naturally as well as improve the soil.[524] The use of green manures (used since Roman times) is currently undergoing something of a revival in an effort to reduce costs, as well as preventing pollution and soil erosion. Kropotkin also advocated preserving bio-diversity and experimenting with the use of native species through the establishment of native reserves and botanical gardens in newly colonised territories.[525]

At the present day degradation and evironmental simplification are compelling farmers to take an ecological approach to their land. Prince Charles' organic hobby farm, or the Australian Landcare Movement, being different instances of a new, and revolutionary, approach to agriculture.[526] An approach that no longer considers the soil as "an inert mineral mass" but rather embraces the "only true conception—that the soil maintains life because it is living matter itself."[527].

Some modern readers of *Fields Factories and Workshops*, have been dismayed by the extent that Kropotkin was a technophile with regard to food production. Some of Kropotkin's suggestions, such as "intensive greenhouse potato production", have been justly "criticised on the grounds that more energy units would be required to increase production than would be produced for use."[528] This is, I believe, just criticism. However, *Fields, Factories and Workshops*, is often

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[524] Kropotkin, Experimental Farms, Nineteenth Century, November 1897, page 815.

[525] Kropotkin, Experimental Farms, Nineteenth Century, November 1897, page 816.

[526] The reader is referred to my own work upon the subject; *Agriculture*, Jura Media, Sydney, 1997.

[527] Kropotkin, Experimental Farms, Nineteenth Century, November 1897, page 820.

[528] Bramwell, A., *Ecology In The 20th Century: A History*, New Haven, Yale University Press 1989, page 87.

mistaken for something it isn't. The central and overriding purpose of the book was to prove Malthus wrong. He argued, that through the intelligent use of the land in both urban and rural contexts, combined with innovative technologies and practices it was easily possible to feed an urbanised, industrialised and densely-populated country like the UK. This was amply proven during the second world war, when the UK successfully fed itself, at least in part, by reintroducing food production back into the city.

Fields, Factories and Workshops, although it is in some important respects a pioneering ecological work upon agricultural and industrial efficiency, the polemical and overtly political dimensions of the book make it quite difficult to gain a true picture of Kropotkin's vision in this respect. It is for this reason that I have presented Kropotkin's views and ideas on human land use and food production, upon the basis of a number of very much less well-known articles, which, I believe, give us a more balanced picture, that is considerably more ecologically 'in tune', than that presented in *Fields, Facotries and Workshops*.

There is no doubt also, however, that Kropotkin, like some other notable ecological thinkers of the 19th and 20th century, such as Chayanov and Howard Odum, shared a degree of technocratic optimism, which many people, including other ecologists, have found unwarranted. Chayanov envisioned "self-sufficient peasants flying into cities to attend a concert, and then returning home to milk the cows"[529] Whilst H. Odum envisioned taking over the management of urban ecosystems through large-scale environmental engineering. Although country people, at least in Australia, may occasionally fly to a city attraction and return the same day, this is hardly an energy efficient means of travel. Eugene Odum, disliked his brother

[529] Bramwell, A., *Ecology in the 20th Century: A History*, New Haven, Yale University Press 1989, page 88.

Howard’s “managerial ethos”, complaining, “we cannot safely take over the management of everything”.[530] Kropotkin’s outlook, I would suggest, fits somewhere in the middle of the spectrum between the sometimes grotesque technophilia of Chayanov and H. Odum and the technophobia of some segments of the contemporary green movement.

The Green City:

Kropotkin extolled the virtues of the "intensive" or market garden approach to vegetable and fruit production.[531] Kropotkin was particularly impressed by the techniques of the urban market gardeners of Paris, Troyes and Rouen, and the peasant farmers of Jersey, Gurnsey and the Scilly Isles. These intensive horticulturalists had developed systems of vegetable and fruit cultivation which were, for their time, some of the most highly efficient and horticulturally sophisticated forms of production available. The Paris gardeners, for example, on small plots within the limits of the city (they were attracted to Paris due to the prodigious quantities of stable manure), managed to export their produce to England. A carefully balanced organic feed was given to the crops on raised beds in frames or greenhouses and nurtured and forced by under soil heating (through steam pipes) and artificial light.[532]

Intensive agro-industrial market gardening methods when combined with ever-more advanced labour-saving technology, would in time allow even large urban agglomerations to be able to grow most of their daily fruit and vegetable

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[530] Hagen, J., *An Entangled Bank: The Origins of Ecosystem Ecology*, New Jersey, Rutgers, 1992 pages 139-40.

[531] Kropotkin, *Conquest of B*read, Ch.XVII.

[532] Kropotkin, *Conquest of B*read, Ch.XVII, and *Fields, Factories and Workshops*, (London, Hutchinson and Co., 1899) London, Thomas Nelson and Sons, 1912, pages 124-133; see also Thomas Smith (F.R.H.S.), *French Gardening*, London, Utopia Press, 1909 (Kropotkin wrote the Foreword to this book).

requirements within the boundary of their own city, village or region. Vegetable and fruit production was to be integrated into urban life creating a more balanced urbarian (urb-agrarian) environment. Social and environmental stability was, he believed, dependent upon an environmentally holistic approach. An approach, moreover, that not only stressed the need to integrate industrial and agricultural production and consumption within the human environment but also with nature's biological and evolutionary tendencies:

> “The large town as well as the villages, must undertake to till the soil. We must return to what biology calls "the integration of functions" . . . the taking up of it as a whole—this is the course followed throughout nature.”[533]

Kropotkin was one of the first thinkers to realise that a scientifically informed approach to organic composting techniques combined with new horticultural concepts, such as glass house culture, might allow the city to feed itself through the intelligent recycling of its human, animal and vegetable wastes.

Kropotkin believed that, in this respect, we had much to learn from the Chinese and Japanese; noting that, through their advanced composting, they were able to maintain dense populations through “utilising what we lose in sewage”.[534] There are many safe ways of treating sewerage and grey water non-chemically ranging from, the waterless toilet, ultra-violet light, sound, reed-beds to vermification. Although these are still very radical ideas to many people in the waste-industry, pilot studies of these techniques are very convincing and could most probably be developed within an urban context.

There is not sufficient space, as was the case with the topic of sustainable agriculture, to enter into the details of how it might be technically possible to create

[533] *The Conquest of Bread*, op.cit., page 99.
[534] Kropotkin, *What Man Can Obtain From The Land*, page 376.

clean and sustainable urban lifestyles, as well as the more utopian goal of a self-sufficient city. The reader is referred to two of my other works, *Agriculture* and *The Green City*, where these matters are dealt with in considerable detail. The decontamination of sewerage and gray water by bio-machines, the vermi-compostification of household waste by large scale worm farms linked to market gardens, the widespread deployment of efficient local clean energy sources and non-polluting public transport systems, and so on are all technically possible, but impossible to implement in an approach to urban land usage which involves every one living a private life in their individual, little brick-boxes.

Kropotkin was really one of the first people to seriously contemplate the notion of the green city, a concept which is currently very popular among a large body of environmentalists, who stress that there should be more focus upon the very big problem of creating clean, sustainable, and even self-sufficient cities.

Just as Kropotkin deplored the separation between government and the governed, town and country, agriculture and industry, he was likewise highly critical of the divisory aspects of modern mass-production with its stress on "efficiency" and its preference for a highly specialised labour force. The human individual must, Kropotkin believed, be regarded as a whole, as having a large variety of capacities, talents and needs and equally capable of both theoretical and manual endeavour. The arbitrary separation of the human individual into mind and body and the theoretical and hierarchical ordering of mind over body had divided society into two classes; those of "brain workers" and "manual workers". This, Kropotkin maintained, was not only a noxious and unhealthy development, but was, in addition, antithetical to improvement and progress. It was only through combining theoretical and manual work that society could initiate the spirit of invention and progress. Theory in the absence of practical manual experience could achieve nothing but drudgery and social division and conflict. Only those who had been trained or acquired knowledge of both theoretical and practical difficulties could improve and understand the practicalities of industrial and agricultural production. To be riveted to a particular machine or task for days or even years at a time served only to alienate, dehumanise and brutalise, completely ignoring the usually varied and multifarious needs and capacities of the human individual. The agro-industrial communes of the future would, Kropotkin hoped, allow for interesting and varied work that encouraged the integration of capacities—creating thereby a more diversified yet unified human individual who would have a choice of a variety of occupations in, communal workshops and urban farms. Labour, when organised around the alternating needs of the free and self-governing city-region, rather than that of an individual factory or farm, would need of necessity to be multifaceted and considerably more varied. The performance of a diversity of social, industrial and agricultural tasks in the home, field and factory would provide work that was both agreeable and healthy and, moreover, useful to both the individual and the larger community.[535] Kropotkin's vision of what one recent commentator has called a "socialist urban landscape"[536] was biologistic rather than cybernetic. The individual city or town, as well as the acephalous federation of them, were to function as a harmoniously co-operating natural system rather than the well-integrated circuit.

Anarchist Federalism:

[535] See *The Conquest of Bread,* Chs. XV, XVI, and *Fields, Factories and Workshops,* Preface and Ch. VII.

[536] Horner, G.M., *Kropotkin and the City: The Socialist Ideal in Urbanism Antipode,* Vol.10, pages 33-45.

Although Kropotkin believed that non-centralised communal structures would form the basic units of anarchist society, he did not consider that a society composed of (small) isolated communities, such as the medieval commune, would provide anything approaching a realistic or realisable alternative. His concept was rather that of the extended neighbourhood community model. Although extended neighbourhood communities could, on account of their size, be self-regulating and self-sufficient (as the Israeli kibbutz amply demonstrates), they could on no account be said to possess the social, intellectual, artistic and material benefits afforded by city life, as Kropotkin hoped. This, however, pre-supposes unreasonably high degrees of communal isolationism, and ignores the possibility of federation, which could arguably generate high levels of inter-community reciprocity and facilitate the development of complex inter-community trade and communication networks. Thus the anarcho-federalist vision, although envisioning a landscape in which overly "large urban places" had given way to smaller cities producing a landscape displaying a more "equal spacing of similarly sized urban places",[537] did not consider that this would result in a landscape composed of insular and territorially isolated communities. Rather, it envisioned a complex, fluid, dynamic and freely federated conception of society in which hierarchical and concentrated administrative, productive and distribution centres had been replaced by voluntary associations within and between the inter-federations of federations of agro-industrial communes.

> “To rack our brains to-day about the details of the form which public life shall take in the future society, would be silly. Yet we must come to an agreement now about the main outlines.

[537] Myrna Brietbart, "Impressions of an Anarchist Landscape", *Antipode*, Vol.7, No.3, Sept. 1975, page 47.

Communes will continue to exist; but these communes are not agglomerations of men in a territory, and know neither walls nor boundaries; the commune is a clustering of like-minded persons, not a closed integer. The various groups in one commune will feel themselves drawn to similar groups in other communes; they will unite themselves with these as firmly as with their fellow-citizens; and thus there will come about communities of interest whose members are scattered over a thousand cities and villages.

The commune will recognize nothing above it except the interests of the league that it has of its own accord made with other communes. Owing to the multiplicity of our needs, a single league will soon not be enough; the commune will feel the necessity of entering into other connections also, joining this or that other league. For the purpose of obtaining food it is already a member of one group; now it must join a second order to obtain other objects that it needs, metal, for instance,—and then a third and fourth too, that will supply it with cloth and works of art. If one takes up an economic atlas of any country, one sees that there are no economic boundaries; the areas of production and exchange for the different objects are blended, interlaced, superimposed. Thus the combinations of the communes also, if they followed their natural development, would soon intertwine in the same way and form an infinitely denser network and a far more consummate "unity" than the States, whose individual parts, after all, only lie side by side like the rods around the lictor's axe."[538]

Kropotkin, in opposition to the Social Darwinists, maintained that the survival of the individual group or species, far from being guaranteed by violent and prolonged struggle, was far better achieved through species co-operation. Co-operation in the face of an, often, hostile environment had, Kropotkin believed, obvious and important advantages which empirically far outweighed those supposedly gained from continuous and unbridled competition. This intuitively

[538] *Paroles d'un Révolté,* Paris, Flammarion, 1885, quoted in Eltzbacher, *Anarchism,* London, A.C. Fifield, 1908, pages 156-8.

obvious yet frequently overlooked dimension of cultural biological and human evolution manifested itself in the nineteenth century through the emergence of ever more complex mutual aid associations. Virtually every need, activity or interest, Kropotkin observed, was catered for by some voluntary organisation, frequently international in nature; the emergence of self-unregarding altruistic organisations such as the International Red Cross or the (voluntary) British Lifeboat Association being, for Kropotkin, the highest expression of humankind's naturally co-operative and interfederative evolution and nature.

> "If we closely scan the development of the human mind in our times we are struck by the number of associations which spring up to meet the varied requirements of the individual of our age . . . already now, Europe is covered by thousands of voluntary associations for study and teaching, for industry, commerce, science, art, literature, exploitation, resistance to exploitation, amusement, serious work, gratification and self denial, for all that makes up the life of an active thinking being . . .
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> . . . To make a list of the associations which exist in Europe, volumes would be necessary, and it would be seen that there is not a single branch of human activity with which one or other does not concern itself . . . We foresee millions and millions of groups freely constituting themselves for the satisfaction of all the varied needs of human beings—some of these groups organised by quarter, street, and house: others extending hands across the walls of cities, over frontiers and oceans. All of these will be composed of human beings who will be combining freely. The tendency toward uniformity and centralisation will be discouraged. Moreover, this society will not be crystallised into certain unchangeable forms, but will continually modify its aspect, because it will be a living, evolving organism; no need of government will be felt, because free agreement and federation takes its place . . . This is the tendency of the

> nineteenth century, and we follow it; we only ask to develop it freely, without any governmental interference . . ."[539]

Technological advancement, Kropotkin argued, can negate rather than enhance the past need for large urban conglomeration. Modern and technologically advanced communication systems largely eradicate the past need for cultural and economic concern to be centred, defined, and confined within large capital cities. Kropotkin appreciated, therefore, that once communication and power supply systems had reached a certain point of development, distance and relative geographical isolation could no longer be realistically viewed as significant. Indeed, the commuter train of metropolitan London, of Kropotkin's own day, concretely advertised the fact that the obstacles of time and space, with respect to the relatively mild forms of isolation involved in the urbarian city commune or anarcho-federalist landscape, would, for the most part, undoubtedly, be eliminated with technical advance.

Intellectual, economic and artistic associations can and, of course, do, as Kropotkin envisioned, operate easily on a world scale. Associations, unlike communes and communities, are not dependent upon direct or unmediated contact, nor subject to technological restraints, territorial or geographical limitations. The cultural and economic pull of the hydrocephalous megopolis, Kropotkin implies, was undoubtedly a unique historical tendency, rather than an historical law, which occurred because hydrocephalisation paralleled the growth of cities as cultural and economic magnets before communication and transport systems became more technically advanced. The recent development of the World Wide Web would be but

[539] From: *The Place of Anarchism in Socialistic Evolution* (pamphlet), London, W.H. Reeves, 1887, and *Anarchism: Its Philosophy and Ideal,* Revolutionary Pamphlets (ed. Baldwin), page 132. See also *Memoirs of a Revolutionist*, New York, Dover, 1970, pages 398-9, and the final sections of *Mutual Aid*, (i.e. *Mutual Aid Amongst Ourselves).*

one more example of humankind's complex and inter-federative potentiality. *Anarcho-federalism* thus provides us with "a technique for establishing a broad network which draws innumerable small groups into a large integrated whole"[540] in which the most effective authority is the small or local unit. In each case the power invested in the variously federated engroupments decreases as one ascends to different and broader levels of federative integration; "so that at the 'top', the ultimate federation has little (or no) influence whatsoever."[541]

Kropotkin's aim was, rather, to produce a *dynamic unity of diversity*, and throughout his writing maintained that "variety, conflict even, is life and that uniformity is death".[542] One of the greatest benefits of communal self-administration and regional federation over centralised organisation was that it preserved the variety, colour and regional or communal variation. Thus, although Kropotkin would have welcomed many of the organisational and structural possibilities of modern city planning and architecture, the overly-standardised and potentially colourless landscape that many of the world's cities have undoubtedly become, contrast sharply with the central thrust of his philosophy. Although there would of course be notable family resemblances in and between the varying human settlements—regional similarities and so on—Kropotkin envisioned an environment in which each commune, city region or regional federation exhibited a recognisable and distinct community life style. Subtle differences from region to region and town to town in time becoming reflected in corresponding differences in their architectural form and appearance; each village, town, city and region of the federative union, like every human face, exhibiting a distinctive yet distinctively human character. The

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[540] Harold Barclay, *People Without Government*, London, Kahn and Averill and Cienfeugos Press, 1982, pages 14-5.
[541] Ibid.
[542] *Anarchism: Its Philosophy and Ideal*, Revolutionary Pamphlets (ed.) Baldwin), page 143.

acephalous federation of agro-industrial communes would ideally develop organically around geographic, ecological and economic features of the natural world. Kropotkin, at varying times, hints with examples at specific federative patterns, e.g. the towns along a river or canal, or a series of ports along a stretch of coast line, that provided glimpses of what he had in mind.[543] In any case the ultimate aim was to create an increasingly heterogeneous landscape with an abundantly mixed and varied usage pattern that was organically integrated with the regional and living diversity of the Earth.

Communal Experimentalism:

Kropotkin always lamented the loss to the Russian revolutionary movement of so many enterprising and spirited people who, hoping to escape from the unbearable weight of autocratic Russia, had gone east to found colonies in Siberia. Even if they succeeded, which was unlikely, isolated experimental communities would at "best", he concluded, "only be a refuge for those who had abandoned the battle, which had to be fought face-to-face with the enemy".[544] Eliseé Reclus, Kropotkin's intellectual and geographical brother, was even stronger in his condemnation. The idea of isolated communal experiments was to Reclus "obnoxious", believing that individuals who wished to construct "a wall between themselves and the rest of their race" could only be motivated by an egotistical and self-centred desire to live in splendid isolation.[545]

Nonetheless, Kropotkin was, deeply and emotionally, influenced by the French (et. al.) utopian tradition such as Fourier. It is significant that Millet's *The Gleaners*—an idealised portrait of the harshness of peasant life—served as the front

[543] See preface to *The Conquest of Bread* (1913 popular ed.), page xiv, and James Mavor, *My Windows of the Streets of the World*, Vol.II, London, 1923, page 104.

[544] *Advice to Those About to Emigrate*, Freedom, London, March 1893.

[545] *Anarchy*, Contemporary Review, London, May 1884, page 637.

piece of several editions of his major economic work, *Fields, Factories and Workshops.* Moreover, although extremely pessimistic about the chance of success, Kropotkin did, as an intellectual gardener, take a slightly more keen interest in isolated communal endeavours which had decided to adopt intensive, scientific and/or experimental agro-industrial gardening techniques, and, on at least one occasion (1896), visited the Clousden Hill Co-operative Colony near Newcastle, England.[546]

Kropotkin certainly did little to discourage communalists from undertaking small-scale experimental ventures by suggesting at one point in his *Fields, Factories and Workshops* a hypothetical agro-industrial village consisting of some 200 families "making the best use of 1,000 acres of shared land". About 340 acres is given over to growing cereals, another 400 acres for grass and fodder for the herds of dairy and beef cattle, and some 20 acres for intensive fruit and vegetable production. Each household would enjoy half an acre for its own use, leaving another 140 acres for workshops, public gardens and squares. It is worth noting, however, a comparable example in *The Conquest of Bread* where he calculated that the 3,900,000 inhabitants of the Departments of Seine and Seine-et-Oise (that is, Paris and its immediate suburbs), constituted as a distinctive region of federated agro-industrial communes, could easily live on their 1,507,300 acres.[547] Thus, Kropotkin did not reject isolated communal experimentationalism emotionally; neither did he reject them on purely theoretical grounds. But rather, by reflecting upon what he had come to "know of the

[546] "Proposed Communist Settlement", *Newcastle Daily Chronicle,* Wed., February 20, 1895, pages 4-5, Freedom, London, Sept. 1895, page 40, Freedom, March 1896, page 69, Freedom, October 1895, page 51, and Hardy, D., *Alternative Communities in Nineteenth Century England,* London, Longman, 1979, pages 181-3. See also Todd, N., *Roses and Revolutionists:The Story of the Clousden Hill Free Communist and Co-operative Colony 1894-1902*, London, Peoples Publications, 1986.

[547] *Fields, Factories and Workshops,* op.cit., pages 237-9, and *The Conquest of Bread,* op.cit., Ch. XVII.

actual life of communist communities" through the personal and written accounts of those who had attempted it.[548]

Quite apart from the inherent weaknesses of isolated experimentationalism as a medium of social life—rivalry, sensory deprivation and the re-domestication of the women members, there were, he believed, an abundance of usually insurmountable practical difficulties which had historically led to the failure of almost every single one. Often settling in unfamiliar and even foreign countryside, lack of money and resources, remoteness from cultural centres, absence of traditional bonds, and the sheer amount of hard physical labour to which the colonists were often unaccustomed. These in turn compounded by a thousand other everyday practical problems would nearly always serve to make isolated communal experiments flickering and fairylike shadows in the history of social landscape. In a long article entitled *Communism and Anarchy* written for the aborted Paris Anarchist Conference of 1900, Kropotkin gives some of his reasons for rejecting experimentalism as a useful device in achieving lasting social change.

> “Progress permits us to see above all, that an isolated town, proclaiming the Commune, would have great difficulty to subsist. The experiment ought, therefore, to be made on a territory—e.g. one of the Western States, Idaho or Ohio—as American socialists suggest, and they are right.
>
> Besides, a small community cannot live long; "brethren and sisters" forced to meet continuously, amid a scarcity of new impressions, end by detesting each other. And if two persons through becoming rivals or simply not liking each other are able by their disagreement to bring about the dissolution of a community, the prolonged life of such communities would be a strange thing, especially since all communities founded up to now have isolated themselves. It is a foregone conclusion that a close association of 10, 20, or 100 persons cannot

[548] *Proposed Communist Settlement*, op.cit.

last longer than three or four years. It would be even regrettable if it lasted longer; because this would only prove either that all were brought under the influence of a single individual or that all lost their individuality. Well, since it is certain that in three, four or five years part of the members of a community would wish to leave, there ought to exist at least a dozen or more of federated communities in order that those who, for one reason or other, wish to leave a community may enter another community, being replaced by new comers from other places. Otherwise, the Communist beehive must necessarily perish or (which nearly always happens) fall into the hands of one individual—generally the most cunning of the "brethren".

Finally, all communities founded up till now isolated themselves from society; but struggle, a life of struggle, is far more urgently needed by an active man than a well supplied table. This desire to see the world, to mix with its currents, to fight its battles is the imperative call to the young generation. Hence it comes (as Tchaikovsky remarked from his experience) that young people, at the age of 18 or 20, necessarily leave a community which does not comprehend the whole of society.

We need not add that governments of all descriptions have always been the most serious stumbling blocks for all communities. Those which have seen least of this or none at all (like Young Icaria) succeed best. This is easily understood. Political hatred is one of the most violent in character. We can live in the same town with our political adversaries if we are not forced to see them every moment. But how is life possible in a small community where we meet each other at every turn. Political dissent enters the study, the workshop, the place of rest, and life becomes impossible."[549]

In my own personal experience, I have met many people who have attempted to form alternative villages in the wilderness. The most common approach in Australia is that of joint-occupancy, where people retain their privacy and the use of

[549] *Communism and Anarchy,* Pts., I and II, Freedom, London, July/August, 1901.

their land. Even in this less utopian scenario, squabbles always seem destined to destroy the venture. I think Kropotkin was fundamentally right in rejecting this approach to social and environmental transformation of society. Kropotkin's approach was rather to reform existing villages, townships and city suburbs into environmentally integrated self-governing communities, rather than attempting to artificially create them.

Conclusion:

Kropotkin was always keen to point out, that the rights and wishes of workers to form unions or peasants agricultural co-operatives was severely restricted by bourgeois governments. Even in 'revolutionary' France "the peasants, whose communal institutions were wrecked, were strictly prohibited, until the year 1884, from entering into any sort of associations, be it only for buying seeds and manure, or for making any permanent improvement of the soils."[550]

However, as legal and other restrictions were lifted, the late nineteenth and the first half, of the twentieth centuries, witnessed a flourishing co-operative movement in both industry and agriculture; building societies, credit-unions, dairy farmer's co-ops, mutual insurance schemes, and so on. The rise of Thatcherism/Reaganism at the end of the 1970's saw a rapid reversal of this trend. In Australia, the latest victim of the de-mutualisation of society maybe the NSW motoring and insurance organisation, the NRMA, which assists drivers when they breakdown for a nominal pre-paid fee, and provides a range of other assistance (maps, servicing, road advice, valuation etc) upon a non-profit basis. Thus, whilst 30 years ago people were 'members' of mutual aid organisations, whether for the purposes of sport, recreation, buying a house, road safety, insurance, etc.,

[550] Kropotkin, *What Man Can Obtain From the Land*, page 360.

‘speculators’ are now ‘share-holders’ and the ‘clients’ are provided these services upon the basis of profit for the benefit of ‘investors’.

The failure of federalism, in both anarchist and non-anarchist organisations, is a major source of criticism of the sort of federalism which Kropotkin envisioned. Federalism has had a very unsuccessful history in recent years. Sports, automobile, hobby, interest, co-operative etc., associations/federations although showing much promise in the 19th and early 20th centuries have tended to become highly centralised, bureaucratic and corrupt monoliths, not dissimilar, or actually aspiring to become capitalist or governmental organisations (e.g. mainstream trade-union federations or the Olympics). Federal constitutions, such as those of Australia or USA quite rapidly became highly centralised with the federal government coming to dominate. Originally conceived as regional or national administrative or umbrella structures, federal power structures often come to completely dominate their ‘members’ becoming an all-powerful national government. Federalism thus becomes a way of letting the highly centralised state or corporate hierarchy in through the back door, so to speak.

Beyond this federations appear inherently unstable. Federations, consisting of just two groupings, often disintegrate under clouds of bitter enmity, in the absence of some ‘higher’ body to reconcile them. It seems clear to me that federalism will not simply emerge as a matter of course between like-minded organisations. In actual fact, factionalism, disintegration or centralism and hierarchy frequently appear to be what actually emerges in most cases. It is perhaps useful to compare the staggering number of different denominations of Christian churches. In the early years of Christianity, there existed a non-centralised/hierarchical federation of Christian peoples covering all of Europe and the Middle East. Denominationalism, bishops and the Pope came later.

I think that Kropotkin's social-ecological vision speaks to our time. For some of the great goals of the 21st century are to conserve nature, and to make our rural life integrated with the dynamics of the natural bio-geography of the Earth; as well as, to develop self-sufficient, urban ecosystems, which mirror nature through recycling all city waste locally in the production of non-polluting, organically-produced, useful products. The green imperative, to live in harmony with the earth, or face the possibility that our species may destroy the earth and the very ecosystems which support us, overrides much social, political and economic theory, at least as traditionally understood. In order to 'save the earth' as a pleasant place for our descendants, as well as those several billion people who live in poverty and environmental squalor at this very moment, it may be necessary to look at the land, whether in the city or country, as part of a local ecosystem with a definite local community, of both human and non-human inhabitants, whose integrity must always preside over our activities.

Likewise, although I believe that the modern individual cannot be made to live, as Kropotkin envisions, in small, directly democratic urban villages, where one might spread manure in the morning, fix the wind generator in the afternoon and write a philosophical treatise in the evening, something that approaches the ideal of low/no impact urban systems, which rely on local clean energy and recycle their organic waste at source, and so on, need to be urgently developed. The maintenance of a suburban wind energy facility, a market garden or child-care facility does not have to be undertaken by the inhabitants, indeed is better, undertaken by professionals or trades-people. Thus, although I believe the communalism that characterises much of Kropotkin's social theory, is unappealing, perhaps, impractical—and in stark contrast to how the majority of modern urban people wish to live—the green imperative may impel us to consider implementing versions of many of the sort of practical, environmentally orientated, bio-regionally[551] integrated, locally self-sufficient systems which Kropotkin envisioned as operating in a post-revolutionary, anarchist-communist-federalist social system.

[551] For an exploration of the concept of bio-regionalism see my '*Ecology, Capitalism and the State*' (1990), republished in my book *Anarchism and Ecology*, Montreal, Black Rose Books, 1997. See Also my *Mapping our Green-Anarchist Future*, Jura Media, Sydney 1996.

Chapter 6

Anarchism, Nature and Organisation

Kropotkin questioned the links between order or organisation and centralized hierarchies. He argued for complete communal autonomy and the organisation of society from the bottom upwards. Kropotkin believed this paralleled the natural principle of local or internal self-regulation/organisation. Although, the various elements of society would be federated each was conceived as a self-organised and "sovereign" entity.[552] A society in which each neighbourhood, community or locality; every "group, circle, branch or section"[553] would be left to organise its affairs according to its own needs and aspirations. The state is unnatural and although, 'statist' history continually promotes the idea that its historical function was the benevolent orderer of pre-social chaos, in reality, statism has been premised upon suppression and elimination of the internal and self-determining, self-organisation of the independent region or community The uniform and centralised administration of society involves the state establishing itself as the sole source of organisational force.

An external organisational force used to be regarded as a necessary pre-condition of natural order. Organisational power rather than resulting from the internal processes of nature was believed to be the product of an all-powerful god above, external or "placed outside" nature.[554]

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[552] Kropotkin, *Anarchism: Its Philosophy and Ideal*, London, Freedom Press, 1897. Reprinted in *Kropotkin's Revolutionary Pamphlets* (Ed. Roger Baldwin), New York, Dover Publications, 1970, page 131,

[553] Kropotkin, *Anarchism: Its Philosophy and Ideal*, page 132.

[554] *Anarchism: Its Philosophy and Ideal*, page 120.

Evolutionary theory, Kropotkin maintained, destroyed forever the notion of ‘pre-conceived harmony in nature’. The “harmony that the human mind discovered in nature” was but the “verification of a certain stability of phenomena”. A durable organisational equilibrium resulting from the “collisions and encounters” of “millions of blind forces” over “millions of centuries”.[555] Nature was not the product of "unknown"[556] and external force or authority, but resulted from a complex and astoundingly long process of self-organisation. ‘Local’ or ‘internal’ self-regulation Kropotkin believed, is an essential feature of living systems, observable in the smallest living particles. Kropotkin concluded that, our changing conception of the universe would inevitably lead humanity to embrace a diffuse, non-centralised and anti-hierarchical explanation of order and organisation:

> “There was a time when man imagined the earth placed in the centre of the universe. Sun, moon, planets and stars seemed to roll round our globe; and this globe inhabited by man represented for him the centre of creation.
>
> Take any work on astronomy of the last century. You will no longer find in it our tiny planet placed in the centre of the universe.
>
> This conception, however, is also disappearing as the other one did. After having fixed all their attention on the sun and the large planets, astronomers are beginning to study now the infinitely small ones that people the universe. Thus the centre, the origin of force, formerly transferred from the earth to the sun, now turns out to be scattered and disseminated. It is everywhere and nowhere. The power which was supposed to govern the system is itself but the result of the collision among those infinitely tiny clusters of matter, that the harmony of stellar systems is harmony only because it is an adaptation, a resultant of all these numberless movements uniting, completing, equilibrating one another. The whole aspect of the universe changes with this new conception. The idea of force governing the world, pre-established law, preconceived harmony, disappears to make room for the harmony that Fourier had caught a glimpse of: the one which results from the disorderly and incoherent movements of

[555] Ibid, page 120-1.
[556] Ibid, page 118.

> numberless hosts of matter, each of which goes its own way and all of which hold each in equilibrium."[557]

Centralist conceptions of natural order have been superseded by a revolutionary reappraisal of nature. The Earth is an insignificant speck in a vast universe without boundary or centre. At the other extreme, particle physicists are revealing that it is not the 'building blocks' of matter that count, but their interaction.

The Kropotkinesque notion of innate decentralised co-operative self-organisation as integral to the evolution and emergence of life is revealed in the actual molecular co-operation within organisms and the self-energising behaviour of simple reactant chemicals. Co-operative decentralised self-organisation is also revealed in the mathematical simulations of emergent life processes.

Self-organisation, Co-operation and Biogenesis:

The topic of co-operative or collective self-organisation involves consideration of biogenesis—the science that concerns itself with how life evolved. Consideration of the various theories involves examining the role of conflict and co-operation. Did biogenesis result from competitive or co-operative processes?

Cells and replicators are not easily conceived as emerging instantaneously, leading to fable-like origin-theories where microbes contained in comets are claimed to have colonised Earth (which says nothing about how life evolved in the first place). Another idea is that simple DNA based replication systems developed first and later began organising proteins. But there is no evidence that the Earth's pre-biotic oceans were the locus for competition or selection of independent strands of RNA or DNA. DNA cannot replicate in the absence of the cell. 'Naked' DNA is also insufficiently robust without the cell's protection. Current scientific thinking favours the RNA-first hypothesis, however, philosophically it remains difficult to see why

[557] Kropotkin, *Anarchism: Its Philosophy and Ideal*, pages 115-8.

coded pieces of either RNA or DNA would evolve in absence of some form in which it could have some function. Similarly, as Cohen remarks, “the many suggestions for the origins of life on clay surfaces or in mineral-oil coarcervates are not illuminating”.[558] Cohen (drawing from Kauffman) in my opinion takes a sensible approach. Life is conceived as originating as an emergent system from the interaction or uniting of a diversity of overlapping and repetitive autocatylytic cycles that mutually support each other’s processes. Cohen’s picture of the origins of life is not a matter of simples complexifying but of organic chemical stabilities intertwining, uniting and completing one another:

> “Caramel is much more complicated chemically than the sugars and fats which were cooked to make it. But, not at all congruent with what we remember of school chemistry. The real chemistry, of clays, rusting, ozone layers and smogs is very recursive, with many autocatalytic steps. Much chemistry is recursive and it could become life by linking up its circles to include local substrates and energy sources; biochemistry didn’t have to repace chemistry (like Einstein/Newton), the chemical processes became living.”[559]

Origins of life theories have generally been divided into two opposing positions. One theory asserts that primordial proteins formed the basis for the evolution of life, whilst the other argues that primordial genes came first. The debate between these two approaches began in the 1930s when Haldane and Oparin developed opposing theories.

Metabolism-first theories were proposed by Oparin after he discovered that solutions of protein sometimes formed aggregates with weak metabolic properties. Haldane, proposed the alternative *replication-first* paradigm when, he became intrigued by the processes of viral replication. Haldane argued that, life may have begun with the evolution of simple virus-like molecular replicators.

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[558] Cohen J., *How Does Complexity Develop*, page 9
[559] Cohen J., *Becoming Maureen—A Story of Development*, page 51

***Haldane's Replication first Paradigm*:**

Virology revealed to Haldane that, "the smallest replication system is simpler than the smallest metabolic system"[560] Haldane built his theory upon the rational principle that: the smallest and simplest systems are most likely to have evolved first.

> "The problem is that nucleic acids are not obtainable under primitive conditions. Unlike the components of RNA that are easily obtainable in abiotic conditions, thymine has never been produced. This means that, "primitive nucleic acids could have been RNAs but not DNAs".[561] For this (and other reasons listed below) speculation and experimentation within the replication-first camp has, in recent years, been focused upon the possibility of a world of RNA replicators:
> "There is a very strong case in favour of an early historical role of RNAs. RNAs can still function as genes. RNA neucleotides are produced by direct syntheses, while DNA nucleotides are synthesized indirectly from ribonucleotides. The universal molecule that all cells employ as energy currency ATP is synthesized from RNA precursors. Many coenzymes contain ribonucleotides or bases derived from ribonucleotides." Although it has "not" been conclusively shown that RNA's self replicate it is known that some have "weak replicate activity."
>
> These compelling facts do not, however, support the further argument that, the "RNA world was a world of replicators"

Mathematical modeling has revealed that, levels of replication error, selfish RNA replication and a tendency to "short circuit" make the RNA-replicator first model extremely unlikely because, it "cannot avoid the various catastrophes that affect all replicators."[562]

Generally it may be said that the replication first (whether DNA or RNA) theory has been the most popular and has since Dawkin's influential work appeared been associated with competitive models that emphasise evolution being driven by competition between primitive replicators. However, the replication model for the reasons outlined above are in many respects implausible.

[560] Barbieri M., *The Organic Codes*, page 134
[561] Barbieri M., *The Organic Codes*, page 124
[562] Barbieri M., *The Organic Codes*, pages 139-142

The metabolism-first paradigm:

The modern metabolism-first hypothesis is associated with the work of S. Fox. Fox's work has been developed in interesting directions by Wicken and Barbieri. I am not so much interested in the truth of the various hypotheses but with the fact that, in contrast to Dawkins all these thinkers present their theses on the origins of life by using co-operative, collective or community metaphors.

Fox in the 1960's investigated the properties of what he called porteinoid microspheres. These are not conventional proteins as their amino acids are arranged in three-dimensional chemical bonds rather than linear chains. Microspheres are stable membrane bound structures with weak catalytic abilities that are able to grow by absorbing proteiniods from their environment and eventually divide in two or form buds. Microspheres exhibit rudimentary metabolic and reproductive capacities.

Fox speculates that, "proteinoid microspheres represent the original terrestrial protocells".[563] The hypothesis claims that RNA entered into symbiotic partnerships with microspheres and co-evolved inside its protective membrane. In other words, a highly developed proto-biotic reproductive cell may have evolved before the internal elaboration of a system of information or replication. The DNA of modern cells did not organise matter, but co-evolved both with and within proteinoid self-organisation. Biogenesis involved an "association of proteins and RNA" antecedent to the development of DNA, where the "microsphere provided a setting for protein synthesis long before the emergence of a well defined genetic code."[564] "Catalytic microspheres", are a very "much more effective agent in commanding energy

[563] Fox, S., *Proteinoid Eperiments and Evolutionary Theory*, in Ho, M., and Saunders P. (eds.), *Beyond Neo-Darwinism*, Academic Press 1984.

[564] Jeffry S. Wicken, *Evolution, Thermodynamics and Information,* Oxford & New York, Oxford University Press, 1987, page 129.

flows”[565], than RNA, and provided both a home and a function for the development of a “primordial ribosomal apparatus of basic proteinoid and RNA”. Rather than the emergence of life being modelled in terms of selection for competing strands of RNA, which later came to some how organise proteins it can be plausibly hypothesised that, the evolution of “RNA-proteinoid complexes”[566] and “nucleic acids” resulted from “interdependence” and “co-evolution”[567], in which “Co-operation is an implicit feature of the catalytic package.”[568]

Computer Simulations of Biogenesis:

In addition to bio-chemical laboratory work bio-mathematicians have also attempted computer simulations of autocatalytic biophysical processes that might enable life-like processes to emerge. Kauffman in the computer laboratory simulates the activities of:

> “...networks of simple polymers--such as small proteins or RNA molecules, that have general, non-specific catalytic activity: that is, they can speed up the rates of chemical reactions, including those involved in making these polymers themselves. As the diversity of these molecules increases, there inevitably comes a point where all the reactions required to make all the components of the network will be catalysed by some member of the set itself. This is because, as the polymer size increases, the number of reactions catalysed increases faster than the number of reactions required to make the polymers. The result is that autocatalytic sets emerge spontaneously; that is sets of polymers with the capacity to catalyse one another’s production so that the whole system functions as a closed set.”[569] catalytic networks have the: “capacity to replicate as connected, causally closed sets...Life doesn’t need DNA to get started; it needs a rich network of facilitating relationships. This is co-operation, mutual support and enrichment.”[570]

[565] Ibid, page 109.
[566] Ibid, page 111.
[567] Ibid, page 124-5.
[568] Ibid, page 113.
[569] Brian Goodwin, *How the Leopard Changed Its Spots: the Evolution of Complexity*, Uk, Weidenfld and Nicolson, 1994, references to 1995 Pheonix Edition, page 174.
[570] Brian Goodwin, *How the Leopard Changed Its Spots*, page 174.

Organisms consist of organised matter and energy flows, where energy is internally stored and used over and over again. Energy is channelled into molecular machines "in which the energy stored in single molecules is released in a specific molecular form and then converted into another specific form so quickly that it never has time to become heat".[571] Through molecular self-organisation "useful work can be done by a molecular system via a direct transfer of stored energy *without thermalisation.*"[572] Living organisms are analogous to computer simulated auto-catalytic systems as they maintain themselves through storing and utilising energy within themselves through self-referential networks.

Biogenesis and Non-Equilibrium Thermodynamics:

Life requires a constant supply of free-energy. This was probably first obtained from thermal sources and from iron and sulphur. Certain bacteria still derive their energy from these sources. However, historically energy derived from sunlight became the dominant source of energy. Because the Earth is an open system, continually bathed in sunlight entropy, rather than creating chaos, provides a path where a free-flowing continuous stream of photons can be utilised by both chemical and living structures. Wicken argues that, prebiotic auto-catalytic structures through capturing and utilising/dissipating energy by means of internal non-equilibrium processes within a constrained or bounded whole, gradually transformed themselves into living unicellular organisms:

> "Microspheres provide that essential ingredient of continuity between the static and the dynamic that the theory of emergence requires. They are equilibrium systems maintained by the principle of free-energy minimisation and requiring for stability certain levels of dissolved proteinoid. They are also open systems exchanging material with, and transforming, their environments... As open

[571] Ho, Mae-Wan, *The Rainbow and the Worm: The Physics of Organisms,* Singapore, World Scientific, 1993, page 30.
[572] Ibid, page 27.

systems, prebiotic microspheres selected kinetic stabilisations that freed them from dependency on prevailing environmental conditions. The emergence of autocatalytic organisations was accompanied by a gradual shift from the deterministic responses to impressed energy gradients that dominated the pre-biotic phase of evolution to the exploitative transformations of environments that characterised its biotic phase. Information emerged under selection for stable patterns of entropy production...Autocatalytic cycles emerge in response to thermodynamic gradients, as ways of accommodating them. The remote-from-equilibrium ordering that correlates with informed autocatalytic flow is a self-organisation. Each strand of RNA and protein is at once a cause and a consequence of the overall autocatalytic process that is the organised whole."[573]

Support for external organisation is a leftover from both religious as well as mechanistic mindframes. A "machine" is externally "organised for functions" that are "external" to it.[574] In the absence of any evidence for an "Organizer" or "external referents", a natural organisation or organism organises itself to capture, store and degrade energy/energy gradients for the purposes of maintaining and propagating itself. "Living systems are 'dissipative structures'; that is, systems that maintain a high degree of *internal* order by dissipating entropy to its surroundings.[575] Living systems or organisms are: "informed dissipative structures, maintaining themselves by autocatalytically focusing resources in the production of their organisational relationships...Systems of *internal* relationships that develop, sustain themselves, and propagate by degrading free energy."[576] Auto-catalysis is essentially circular and self-referential organisation of "kinetic pathways that generate products that catalyses itself directly or catalyses one that feeds into it", such that "antecedents and consequents form" themselves into "closed loops".[577] Life is thus a process in which closed or self-referential internal catalytic relationships whose "processes" are

[573] Jeffry S. Wicken, Evolution, Thermodynamics and Information, Oxford & New York, Oxford University Press, 1987 pages 125-9

[574] Wicken, *Evolution, Thermodynamics and Information,* pages 41 and 60.

[575] Ibid, page 31.

[576] Ibid, page 60.

[577] Wicken, *Evolution, Thermodynamics and Information,* page 121.

“controlled endogenously”[578] are replaced by “*informed internal* relationships”.[579] Life was not achieved by “outside agents”, rather DNA was the result of “*internal* products” of the organism gradually coming to life.[580] The emergence of living process and information was “evolution from within”[581] or “internal self-assembly”[582]; of “evolution from the inside out and bottom upward.”[583]; of “‘order-within’ versus ‘order-between’”; of “intra-order versus inter-order”, in which, “aliveness”, was “achieved by stages”.[584]

Barbieri’s RibotypeTheory of The Origin of Life:

Barbieri theory builds upon the non-Haldanian metabolism-first model of chemical evolution because organic systems or structures like microspheres are the only examples yet produced of something that could potentially produce or house simple RNA’s (p. 145). Fox however, envisioned co-operative or symbiotic relationships between microspheres and simple RNA’s, whereas Barbieri regards such structures only as a potential producer of RNAs.

Barbieri most wants to differentiate his theory from the ‘RNA world’ proposed by the neo-Haldanians. These perspectives (popularized by Dawkins) begin their story with ribonucleoproteins. Barbieri believes that, these are structurally “too advanced” to have emerged by purely chemical evolution. He coins the term *ribosoid* to describe other sorts of more simple molecules of RNA, or RNA and peptides. The term *ribotype world* is used to differentiate the *ribosoid world* from the *RNA world* dreamed up by the replication-first camp. *Ribotype world* is a hypothetical

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[578] Sidney Fox, *Proteinoid Experiments and Evolutionary Theory*, page 15.
[579] Wicken, *Evolution, Thermodynamics and Information*, page 15.
[580] Sidney Fox, *Proteinoid Experiments and Evolutionary Theory*, page 51.
[581] Sidney Fox, *Evolution outward and forward*, page 24.
[582] Matsuno K., *Open Systems and the Origin of Protoreproductive Units*, in Ho M. and Saunders P. (eds.), *Beyond Neo-Darwinism*, Academic Press 1984, page 62.
[583] Sidney Fox, *Evolution outward and forward*, page 29.
[584] Sidney Fox, *Proteinoid Experiments and Evolutionary Theory*, page 50.

primordial world of metabolically active chemical proto-cells/vesicules producing, ingesting and housing the evolution of primitive RNA's that conceivably may "have been polymerising ribosoids":

> "Together with polymerizing ribosoids, ribogenes were also evolving, which means that precellular systems had genomes predominantly made of RNA's"[585]
> "According to the ribotype theory primitive ribotypes developed a ribophenotype (the ribozymes) and a ribogentype (the ribogenes)and these last two categories evolved into what we now call phenotype and genotype"[586]

Complexity scientists working in mathematical-chemistry, such as "Kauffmann and Dyson" show that:

"the probability of a transition from chaos to order increases with the complexity of the system, but, the jump of primitive metabolic systems from chaos to order is in this case only a question of statistical probability and energy conditions. During post-chemical evolution, instead, a new type of antichaos appeared; an order that was based on conventional rules of corrspondence between two independent molecular worlds, and it was from these first natural conventions that the genetic code finally emerged."[587]

Genetic and other Organic Codes:

> "We are accustomed to think of RNA's and ribonucleoproteins as intermediaries between genotype and phenotype", but, "as phenotype is the seat of metabolism and genotype the seat of heredity, so ribotype is the seat of genetic Coding. *The distinction between phenotype, genotype and ribotype reflects the distinction between energy , information and meaning,* the most fundamental of Nature's entities"[588]"the cell is not a duality of genotype and phenotype but a trinity made of genotype, phenotype and ribotype. The ribotype is a cell category that has the same ontological status as genotype and phenotype, but has a logical and historical priority over them." "Codes in addition to energy and information require *meaning*. The existence of the genetic code proves that it is as natural information. *Meaning is an object which is related to another object via a code*." "Correspondence between two independent worlds need not be the result of conscious activity. The only logical necessity is that the codemaker is *an agent that is ontologically different* from the objects of the two worlds. In the case of the genetic code the codemaker is the ribonucleoprotein system of the cell."[589]

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[585] Barbieri M., *The Organic Codes*, pages 145-7
[586] Barbieri M., *The Organic Codes*, page 158
[587] Barbieri M., *The Organic Codes*, page 157
[588] Barbieri M., *The Organic Codes*, page 157
[589] Barbieri M., *The Organic Codes*, page 1

Barbieri asks us to take the notion of codes in a literal sense and not just in the "metaphorical sense" to which it has been "largely" used up to now: "organic codes are not metaphorical but real…A code is a correspondence between two independent worlds, and a real organic code requires molecules that perform two independent recognition processes. In the genetic code these molecules are the transfer of RNAs, but, equivalent ones are used in other processes, e.g. signal transduction and splicing. Many other cases are expected to turn up. Gabius provides evidence for a sugar code while Strahl et. al. discovered a histone code. The more we learn about organic codes the more they turn out to be every bit a real as the genetic code."[590]

Copymakers and Codemakers:

> "Some molecules started making copies of polymers, and for this reason we call them *copymakers*. Other molecules made coded versions of the copies, and we call them codemakers. On the primitive Earth the copymakers could have been RNA replicases and the codemakers could have been transfer RNAs." "The formation of a random chain of subunits is accounted for by the ordinary laws of thermodynamics and does not require any new physical quantity. But when a copymaker makes a chain, something new appears: the sequence of subunits becomes *information* for the copymaker. In a similar way, when a codemaker takes a chain of monomers on one kind to produce a chain of monomers of a different kind, something new appears: the second chain becomes the *meaning* of the first one. It is only the act of copying that creates information and it is only the act of coding that creates meaning." "The substance of the replicator model is that all that matters in life is information, and that all that matters in evolution is the replication of information with occasional mistakes. Information and meaning are two independent entities, copying and coding are two independent processes, and the codemaker between genes and proteins must be a third party because otherwise there would be no real code. The replicator model is not wrong, but incomplete, because what matters in life is replication and coding not replication alone."[591]

[590] Barbieri M., *The Organic Codes*, page 3
[591] Barbieri M., *The Organic Codes*, page 159-162

> "The reason for adopting DNA genome was probably the fact that DNA is more stable than RNA. Also RNA's linear molecules can be used both as genes and messengers, and in the ribotype world these two roles were performed by the same molecules, which could have created some confusion. The necessity to distinguish between genes and messengers could well have been a reason for substituting the RNA genes, and it is not surprising that DNA was chosen because it is easily obtained from RNA and conveys exactly the same information."[592]

Barbieri accepts that the "formulae of energy, entropy and information apply to all natural processes, irrespective of their mechanism"[593], but, in contrast to Wicken argues that this paradigm is inadequate by itself:

"The genotype (information) and phenotype (energy) dichotomy divides two different biological functions, heredity and metabolism. This scheme transformed the energy-based biology of the 19th century into the information based biology of the 20th." "Johannssen's duality" was "legitimized" with the development of the concepts and implication of "computer softeware and hardware." Barbieri predicts that, the "informatic biology of the twentieth century is going to be replaced by a semantic biology which acounts for the existence of organic codes at the very heart of life."[594]

Decentralised Self-Organisation of Genomes:

Genomes, have traditionally been characterised as hierarchical and centralised structures. A viewpoint favoured by Weismann at the end of the 19th century with whom Kropotkin engaged in a long and bitter polemic.[595] In fact genomes are unimaginably diffuse in their operation. Different and widely differing parts of the genome are involved in initiating a characteristic or organ. These differing localities are not brought together by centralised agencies but work within a

[592] Barbieri M., *The Organic Codes*, page 173
[593] Barbieri M., *The Organic Codes*, page 89
[594] Barbieri M., *The Organic Codes*, page 217-19
[595] See Kropotkin's Book, *Evolution and Environment*, Black Rose Books 1995

complex epigenetic federation linked by an array of positive and negative feed back systems with the cell, the body and the environment. There is no one-way linear, additive, centralist and hierarchical flow of information from DNA to RNA to protein. Processes such as reverse transcription ensures there is a two-way flow of information between the cell and body. Attempting to discover a controller for the controls that turn genes on and off in epigenetic or developmental process "soon gets into an infinite regress that fails to explain how living organisms can become organised".[596] To search for an organisational pointer is to search for a needle in a haystack, when the needle doesn't even exist.

Self-Organisation, Non-centralisation and Morphogenic fields:

Kropotkin felt that experimental studies of regeneration conducted by Josef Nusbaum, "where a new organ" grew out of "a re-differentiation of the elements of a neighbouring, quite different organ",[597] posed conceptual problems for centralist or military-like explanations of growth and development promoted by Weismann.

Recent studies of the growth of large single-cell algae have revealed that, their often beautiful shapes, instead of being due to the activity of genes are, rather due to the non-linear, dynamic, self-ordering behaviour/patterning of the cell's various chemical and bio-chemical ingredients interacting as a morphogenic field within a bounded space; created by, and subject to, various internal and external physio-chemical constraints. Although this idea began to develop at the opening of the 20th century, the notion of the morphogenic field is most pertinently associated

[596] Ho, *Genetic Engineering*, page 103. This provides the best introduction to genetics for radicals. See my review for an overview, *Genethics and Reality*, Direct Action (Manchester, UK), #18 Spring 2001, pages 26-7 or go to geocities.com/jura media/.

[597] Kropotkin, *Evolution and Environment*, page 197

with the “celebrated Vienna-born embryologist Paul Weiss”,[598] in the 1930’s and 40’s. Computer technologies have led to a better understanding of cellular and multi-cellular development.

Computer simulations of “calcium patterns and mechanical strain”[599], roughly equivalent to those experienced and created by algal development, resulted in similar structures to those of the algae themselves. Moreover, when algae are mutilated and their nucleus removed, “regeneration” or “morphogenesis, occurs in the absence of a nucleus”. Although “nuclear products” are necessary, as shown by the fact that mutilation and regeneration will not occur indefinitely in the absence of the nucleus, the organisation of the “actual structure, seems to be the job of the cytoplasm.”[600] Thus biological organisation in many crucial aspects is not programmed by the genes but is a product of the natural self-ordering ability of an excitable medium undergoing growth or transformation.

Developmental processes in multicellular organisms is not solely dependant upon ‘ordering’ genes. Rather, order comes for free, in that, a large number of ‘simples’, in this case cells, “generate distinctive types of dynamic process in which genes play a significant but limited role”[601] Notwithstanding the “gene-centred biology” of the recent past, “organisms cannot be reduced to the properties of their genes, and have to be understood as dynamical systems with distinctive properties that characterise the living state.” The recent “shift of perspective from genes to organisms” [602] reveals that the forms which plants and animals assume results from the distinctive properties that interacting cells typically generate within given

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[598]Sapp, J., *Beyond the Gene: Cytoplasmic Inheritance and the Struggle for Authority in Genetics*, Oxford University Press 1987, page 14.

[599] Brian Goodwin, *How the Leopard Changed Its Spots*, page 99.

[600] Ibid, page 85.

[601] Ibid, page XIII.

[602] Brian Goodwin, *How the Leopard Changed Its Spots*, pages 2-3.

constraints. Although genes can alter the timing of the expression of different patterns, as well as other important parameters, ‘morphogenic’, ‘epigenetic’, ‘generative’ or ‘excitable’ fields exhibit remarkable similarities in terms of form and characteristic dynamic patterns of spatial order, which can be observed in a wide range of phenomena, for example, certain chemical reactions, the aggregation of slime mould amoeba, the growth of a flower, to the development of limbs and brain waves. Bio-mathematicians are able to model or reproduce these natural, non-centralised, self-organisation patterns of interacting cells: “Despite differences of emphasis, there is a fundamental sense in which all morphogenetic field models are equivalent. They depend upon excitable dynamics to initiate large-scale or global pattern formation.”[603] “These systems produce something out of nothing...There is no plan, no blueprint, no instruction about the pattern that emerges. What exists in the field is a set of relationships between the components of the system, such that the dynamically stable state into which it goes naturally is the generic or typical state of the field...”[604] “Morphogenetic fields have a definition as precise as any field used in physics...complexity gave us order for free”[605]

The morphogenic field of the meristem exhibit similar patterns of phyllotaxis in all plant species because they “result from the co-operative response of the cells to physical constraints” from “mechanical strains in the surface layer of epidermal cells acting as an elastic shell that resist the pressure exerted by the growing tissue underneath.”[606] These “structural constraints explain the distinctive features of biological form.”[607] Though there are three types of pattern in the meristem and “four

[603] Ibid, pages 97.
[604] Ibid, page 49.
[605] Ibid, pages 88 and 92.
[606] Ibid, page 108.
[607] Ibid, page 134.

basic whorls of organs in flowers"[608], the development of the flower and its organs are transformations of the leaves. These "different patterns are not fixed characteristics...all the patterns can be generated simply by changing growth rates."[609] Such transformation are known as "homeotic,...because, one organ is replaced by another structure that belongs to a similar set of natural forms."[610] As with plants, studies of homeotic transformations in animals, reveal, "that structures which look quite different, such as legs, wings and eyes...are in fact easily transformed into the other by the effects of single genes."[611]

Form is more autonomous from inheritance than was previously thought. Higher order or regulatory genetic processes are reliant upon robust, dynamical, non-living, self-organising processes at lower levels. The old model of the DNA creating or controlling biological organisation is giving way to a new model in which DNA "co-operates"[612] with abiotic physical processes.

Social and local Self-Organisation among Animals:

Logically this would be the place to discuss how organisms, from bacteria to whales, self-organise themselves into social groups but most readers will be familiar with the arguments as first presented by Kropotkin in his book *Mutual Aid*.

Self-Organisation of the Ecosystem and Biosphere:

There no lord over nature. The ecology of natural systems, doesn't require internally or externally, even limited concentrations of organisational force.

Natural systems, at whatever level, be it an individual, an ecosystem or, indeed, the biosphere itself, must be represented as dynamic, self-organisational

[608] Ibid, page 125.
[609] Ibid, page 107 and 119.
[610] Ibid, page 123.
[611] Brian Goodwin, *How the Leopard Changed Its Spots*, page 125.
[612] Ibid, page 128.

configurations; as non-equilibrium stabilities of enormous complexity in which life, without being subordinated to a central organ, maintains order within itself. In ecosystems each individual or species adapts its behaviour according to the dictates of environmental systems in which they co-operate. “Each”, Kropotkin argues, “react on all the others”.[613] Everything is adapted, ordered and organised to, and about, everything else. The decentralised, non-hierarchical, self-organisation of living systems is best illustrated by considering how by micro-organisms regulate the biosphere. The notion of the Earth as a living being is an ancient one. This ancient notion was replaced, through the 18-20th centuries, by a new scientific variant, in which the Earth became conceived as a self-organised system. Historically, this shift in perception is particularly associated with the ideas Humboldt (1769-1859) and Reclus (1830-1905)[614]. Humboldt inspired Reclus and Kropotkin, and Kropotkin and Reclus undertook a considerable amount of geographical and political work together.[615] Later, pioneering biogeochemists of the early 20th century, such as V. Vernadsky (1863-1945) and E. G. Hutchinson began to explain these concepts in modern terms, based upon the empirical study “of the exchange of materials between the living and non-living components of the biosphere”[616] “The biosphere is a highly integrated and self-organised cybernetic or controlled system. But control at the biosphere level is not accomplished by external, goal-orientated thermostats and chemostats …Rather control is internal and diffuse involving hundreds of thousands of feedback loops and synergistic interactions in subsystems like the microbial

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[613] *Anarchism: Its Philosophy and Ideal*, page 120.

[614] Jacques Grinevald, *Sketch for a History of the Idea of the Biosphere*, in *Gaia in Action*, Peter Bunyard (ed) UK, Floris Books, 1996, pages 36-7.

[615] See Reclus E. (Graham Purchase, Ed.) *Man and Nature: The Impact of Human Activity on Physical Geography and Concerning the Awareness of Nature in Modern Society*, Sydney, Jura Media 1995. See also my *Anarchism and Ecology: The Historic Relationship*, in Purchase G. *Anarchism and Ecology*, Montreal, Black Rose Books, 1997, pages 33-74

[616] Odum, E., *Ecology and Our Endangered Life-Support System*, page 113, see also a Jacques Grinevald, *Sketch for a History of the Idea of the Biosphere*, pages 44-5.

network that controls the nitrogen cycle."[617] This planetary-scale self-organisation is predominantly mediated by bacteria that created and maintain the atmosphere and oceans. Animals and Plants only take up the last sixth of the total period of biological evolution. They are relative latecomers, who inherited a stable and habitable atmospheric and aquatic environment, pre-established by their microbiological ancestors. The regulation of the atmosphere by micro-organisms (including bacterially derived organelles in plants and symbiotic relationships in corals etc.) is unimaginably diffuse. Billions of bacteria inhabit every cup of water, inhabit every micro-niche and lay at the basis of all ecosystems. Hierarchical analogies cannot be used to describe nature because the biosphere, the most extensive and important self-organising system of all, results from the activities of its smallest and most primitive inhabitants without the need of any help from higher organisms.

Decentralised Self-Organistion of the Brain:

Kropotkin argued that in the nervous system “each neurone of an organism is a separate unit, and can be compared to an amoeba-like organism, possessed of its own life, its own irritability, and its own capacity to receive irritations from without and to answer them.”[618]

Contemporary science reveals that, although different parts of the brain associated with particular activities, these distinct parts of the brain usually work with other distinct parts, that are distributed in widely differing locations and are brought together without recourse to a central governing region. A complex interplay of localisation, de-localisation and non-localisation that create powerful federative epiphenomenal networks. Operations involving brain bisection such that the left and

[617] Odum, E., *Ecology and Our Endangered Life-Support System*, page 63.

[618] Kropotkin, Evolution of the Nervous System, *Recent Science*, *The Nineteenth Century Magazine*, July 1897 page 28

right hand hemispheres are completely separated reveal that, in reality we have two brains rather than one. Even more remarkably, brain-bisection patients who have had the 200 million fibres that connect the two halves with one another behave, apparently quite normally. Only specialised psychophysical tests are able to reveal how such an apparently severe handicap appears to be effortlessly overcome. Thus, although our brain cells are not generally renewed like our blood or liver cells, they are capable of radically re-networking themselves, both organisationally and physiologically. Empirical evidence points to a non-centralised and federative interpretation of the workings of the brain characterised by a high degree of local autonomy.[619] The "normal mind is not beautifully unified but rather problematically yoked-together bundle of partly autonomous systems".[620]

Anarchism, Hierarchialism and Complexification in Nature

Organisation from the Simple to the Complex:

States organise society hierarchically 'from the top down'. Anarchist's hope that regions and peoples can organise themselves 'from the bottom upwards'. Anarchism beginning with "simple" self-organisation of the particular branch or locality hopes that, through "free federation" of economic, recreational, scientific etc., institutions society without government will complexify itself. Anarchism,

[619] R. W. Sperry, *Some Functional Effects of Sectioning the Cerebral Commissures in Man,* Proceedings of the National Academy of Sciences, 1962, pages 1765-9. An interesting philosophical overview can be found in Nagel T., *Brain Bisection and the Unity of Consciousness*, in *Mortal Questions*, New York, Cambridge University Press, 1979, pages 147-64.

[620] Gazzaniga, quoted by Dennet, D., in Kessel, Cole, Johnson (eds.), S*elf and Consciousnous*, New Jersey, Erlbaum, 1992.

Kropotkin asserts, in accordance with the natural principle of local or internal organisation[621] aims at the abolition of the state and its replacement by:

"social organisation from the simple to the complex by means of free federation of popular forces...according to mutual agreement and to the infinitely varied, ever-changing needs of each locality".[622]

Ideally, at the 'top', these non-territorial federations of locals exhibit increasing organisational complexity, rather than more authority.

Nature is structured as levels of increasing complexity. No god, state nor master organises it. In natural systems, one integrated level is no more organisationally important than any other. Organisational participation rests with individual organisms as much as it does within the entire system. Odum claims that, unlike state capitalist hierarchies, natural ones are "reversible", and can be viewed from the "bottom up".[623]

Emergence, Self-Organisation and Natural Levels:

'Emergence' was invented by George Lewes (1817-1878) to distinguish predictable or convergent transformations from unpredictable, novel or emergent events. Emergents are novel, quality, progressive and unpredictable events. These ideas of discontinuous evolution contrasts strongly with Darwinian uniformitarian gradualism. Lewis hoped emergences might soon be ex-pressed as mathematical formulas. Lewes' disciple, Morgan (who altered his views upon animal societies after reading Kropotkin's *Mutual Aid*[624]) interpreted emergence in hierarchical or pyramidal terms. Emergences and natural hierarchies are important concepts in contemporary ecological, mathematical and evolutionary theory. In these sciences

[621] See previous ASR article upon self-organisation
[622] Kropotkin, *Anarchism: Its Philosophy and Ideal*, page 133
[623] Odum, E., *Ecology and Our Endangered Life-Support System*, page 25.
[624] See K Ethics

hierarchy is used neutrally to describe interacting levels. Unfortunately hierarchy has political meanings and fails to adequately clarify the scientific concepts.

In scientific literature hierarchical concepts are used to characterise mutually interdependent interacting levels of activity (also evolutionary jumps) beginning with the smallest sub-atomic particles, and outwards or upwards through chemical stabilities, genomes, cells, multi–cellular animals/plants, ecosystems and social systems.

Many contemporary evolutionists argue that differential sorting mechanisms over geological time-scales occur at all levels; at the level of the social group, genome and ecosystem. Focusing upon either individual, group or species selection (the term natural selection only describes 'sorting' among individuals) obscures the fact that sorting processes occur in all these levels or platforms (alternative terms to hierarchy but without the political connotations) and that different rules operate at different levels.

Hierarchical concepts are useful in capturing certain elements of natural organisation, but, the self-referential nature of life's unfolding contradicts hierarchy as conventionally defined:

> "It must recognised that nature is not a thing, reducible to ultimate building-blocks of things. Nature is hierarchically expressed, with a common body of laws and constraints at each level. Patterns of macro-evolution are not derivable from patterns of micro-evolution; species selection is not derivable from individual selection. Second, there must be a revival of the organism concept. The issues of organism and hierarchy are closely related, but not coextensively so. Hierarchy has become a popular word during the search for middle ground between reductionism and holism. It is not the right word in all cases. Hierarchy implies ontological layers that communicate with each other somehow. Biological nature is not like this. It is a web of relationships that fit with, and are defined by, each other. Nature is organismically constituted."[625]

[625] Wicken, page 7.

The Earth is a super-system whilst a bacteria is an organism—an organism is one sort of natural system. Organismic or Systems levels are dependant upon but not reducible to previous organisational platforms. They are the irreversible and creative result of previous emergences. Unlike the "non-hierarchical simplicity" of "crystallographic order" in which "its essential completeness" is restricted to "a single static level of structure", living organisms and systems "must be expressed hierarchically because no single level of structure contains the grounds for its own production or stability". The problem with using the term hierarchy to describe mutually interdependent parts of organisms or systems is that, the order is achieved through a "whole system of relationships"[626], in which the "parts or levels in hierarchies are mutually defining and co-evolving"[627]. "Organic order is maintained by functional interactions "between hierarchical levels, such that neither has causal or ontological priority over the other".[628] Notions of circular hierarchies, where information and order is multidirectional and integrated into a holistic or emergent organisational web of interdependent relationships, stretches the concept to describe systems that are the opposite of what is commonly understood by hierarchy: programmatic, centralised, vertical or top-down command systems where subordinates follow the instructions of superiors.

Ecosystems, genomes and organisms are characteristically interacting with all layers of organisation simultaneously such that they are in constant communication or co-activity through circular or web-like multi-directional patterns of local autonomy and global interdependency, that cannot be described in hierarchical terms but rather in terms of bottom upward self-organisation of an

[626] Wicken, *Evolution, Thermodynamics and Information,* Oxford University Press, 1988,page 50.

[627] Ibid, page 167.

[628] Ibid, page 137.

organismic or systemic whole. Although the notion of organisational layers is integral to understanding nature, hierarchy is a term that has been used inadvisably by evolutionary and complexity scientists. In Ecology, for example, hierarchy is often anthropomorphised. Odum, in a table depicting ‘levels of organisational hierarchies’,uncritically compares human geo-political and military hierarchies with ecological ones. Although he states that, unlike human political and social hierarchies, natural hierarchies are “reversible”, this captures the idea of a two-way linear highway rather than the integrated ecosystem.[629] Moreover, the ecological classification of these non-existent human categories is problematic. Systems concepts can be applied at different levels and scales; from a village pond to the biospheric super-system. In bio-geography there are “no agreed classification scheme of ecosystem types”[630] (biomes, bioregions etc., are general and indecisive terms). Hierarchical concepts are derived from Aristotle’s chain of being and 18th century natural theology. They fit very awkwardly with ideas of organisms and ecosystems. Odum’s comparison of social and biological hierarchies implies governmental stratification is natural because biological systems are similarly organised. In fact bio-systems operate in radically decentralised ways. Although there are socially generated hierarchies in animal groups that can be compared with human ones, hierarchical analogies fail to capture the essence of bio-systems.

Self-Organisation from the “Simple” to the “Complex”:

Kropotkin in common with most evolutionary thinkers thought evolution proceeded from the *simple* to the *complex*. Kropotkin also thought that, the development and functioning of organisms resulted from the ongoing self-organisation of numerous independent co-operating *simples*. Complexity evolved and

[629] Odum, E., *Ecology and Our Endangered Life-Support System*, pages 25-6.
[630] Odum, E., *Ecology and Our Endangered Life-Support System*, page 60.

was maintained by autonomous federations of simples. Moreover, co-operative networks are a natural and desirable form for society. The traditional idea of a *complex* orderer programming *simples* to generate complexity requires prior organisation in the form of a God or the DNA-first hypothesis.[631] However, living systems are the result of co-operative complexity emerging through dynamic non-equilibrium patterns of orderly interaction premised upon energetic and informational feedback between *simples* as part of an integrated network.

Simulations of the evolution of *complex* order from large numbers of a few different *simples* (e.g. on/off simulating active/inactive or abcd acdb etc., equalling molecular chains) are programmed with basic rules:

> "Reynolds' program captures flocking behaviour in birds. A collection of autonomous, birdlike agents—"boids"— are placed in an on-screen environment of walls and obstacles. Boids follow three behavioural rules:
> 1. Maintain a minimum distance from other objects in the environment.
> 2. Match velocities with boids in its neighbourhood.
> 3. Move toward the perceived centre of mass of boids in its neighbourhood.
>
> None of these rules say, "Form a flock". The rules are entirely local, referring only to what an individual boid can do in its own vicinity.
> If a flock were going to form at all, it would have to do so from the bottom up, as an emergent phenomenon. And yet flocks did form, every time. Reynolds could start his simulation with boids scattered around the computer screen completely at random, and they would spontaneously collect themselves into a flock that could fly around obstacles in a very fluid and natural manner. Sometimes the flock would even break into subflocks that flowed around both sides of an obstacle, rejoining on the other side as if the boids had planned it all along. In one of the runs, in fact, a boid accidentally hit a pole, fluttered around for a moment as though stunned and lost—then darted forward to rejoin the flock as it moved on. Reynolds insisted that this last bit of business was proof that the behaviour of the boids was truly emergent. There was nothing in the rules of behaviour or in any of the other computer code that told that particular boid to act that way."[632]

[631] See my discussion in ASR…
[632] *Complexity: The Emerging Science at the Edge of Order and Chaos,* USA, Simon & Schuster, 1992, pages 241-2.

Bio-mathematicians simulate biogenesis by programming letters with varying catalytic and reaction strengths that are able to join up with one another to form longer chains without being instructed to do so. Autocatalytic simulation of biogenesis suggests that a critical level of complexity could have been achieved by strings of interacting polymers forming themselves into loops and then self-organising webs. As the system evolves it undergoes qualitative and irreversible change, achieving greater levels of complex, co-operative order.

> "Reductionist biology investigates complexity by dissecting life into basic components. Complexity science is superior to reductionism by revealing that complex non-equilibrium order belongs to the system rather than the sum of its parts. Reductionism failed because, emergent patterns could not "be predicted from a knowledge of the properties of the component parts in isolation."[633]:
> "The phrase 'life at the edge of chaos' describes the life-like behaviour of cellular automata and the existence of a transition region that separates the domains of chaos and order. In this region all the parts of the system are in dynamic communication with all other parts, so that the potential for information processing in the systems is at a maximum. This state of high communication and 'emergent' computation is a condition that provides maximal opportunities for the system to evolve..."[634]
> "The most surprising lesson we have learned from simulating *complex* physical systems on computers is that complex behaviour need not have *complex* roots. Indeed tremendously interesting and beguilingly complex behaviour can emerge from collections of extremely *simple* components...Instead of writing global, top-down specifications for how the flock of boids should behave, or telling them to follow the lead of one Boss Boid only the three simple rules of local boid-to-boid interaction are used. localism allowed the flock to adapt to changing conditions so organically. The rules always tended to pull the boids together. The tendency to converge was only a tendency, the result of each boid reacting to what the other boids were doing in its immediate neighbourhood. When a flock encountered an obstacle such as a pillar, it had no trouble splitting apart and flowing to either side as each boid did its own thing. Try doing that with a single set of top-level rules. The system would be impossibly cumbersome and complicated, with the rules telling each boid precisely what to

[633] Brian Goodwin, *How the Leopard Changed Its Spots*, page 73.
[634] Brian Goodwin, *How the Leopard Changed Its Spots*, page 170.

> do in every conceivable situation. In fact top down simulations look jerky and unnatural, more like an animated cartoon than like animated life. It is effectively impossible to cover every situation and top-down systems are forever running into combinations of events they can't handle. They tend to be touchy and fragile, and they all too often grind to a halt in a dither of indecision...The way to achieve lifelike behaviour is to simulate populations of *simple* units instead of one big *complex* unit. Use local control instead of global control.
> Let the behaviour emerge from the bottom up, instead of being specified from the top down. Focus upon ongoing behaviour instead of the final result as living systems never really settle down. Life does transcend mere matter not because living systems are animated by some vital essence operating outside the laws of physics and chemistry, but because a population of *simple* things following simple rules of interaction can behave in eternally surprising ways."[635]

The influence of anarchist ideas in the 1960's led to a popularisation of the idea of organisation from the bottom upwards. Complexity science has also generated similar thinking leading many both in and out of the field to believe that, universal bottom up laws of complexity might be discovered that could possibly explain a wide diversity social and scientific phenomena. This is because of the highly predictable nature of many convergent emergences generated by the behaviour of simples following simple rules. Cohen, correctly in my view, believes that this is not much of an improvement upon religious fundamentalism of the past: "The search for a single, ultimate system of natural laws is fundamentalist" and the "theory of everything at the bottom…mirrors, in an appropriately inverted way, the 'God at the top' thought patterns of fundamentalist religion"[636] Kropotkin did not fall into the fundamentalist trap as he thought that all laws, even scientific ones, could never be permanent or universal. Cohen uses the example of "Langton's Ant" to illustrate how computer experimentation with the evolution of complexity has failed to reveal the existence of fundamental bottom up laws of complexification.

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[635] *Complexity*, pages 279-80.
[636] Cohen J. and Stewart, I., *Simplicity in a Complex World*, Futures, 1994 Vol 26 #6 page 654

“Rule-based systems exhibit features on many levels, and emergence occurs when low-level rules generate high-level features. A big mystery is why this happens. But it seems undeniable that it happens…A simple example of emergence occurs in Langton’s ant, a cellular automaton invented by Chris Langton…Begin with a grid of squares, which can be in one of two states: black or white. The ant starts out on the central square in some selected direction and moves one square in that direction and looks at the colour of the square it lands on. If it lands on a black square then it paints it white and turns ninety degrees to the left. If it lands on a white square it paints it black and turns ninety degrees to the right. It keeps on following those same simple rules forever. But those rules produce some surprisingly complex behaviour. For the first 500 or so steps, the ant keeps returning to the central square, leaving behind it a series of rather symmetric patters. Then, for the next 10, 000 or steps or so, the picture becomes very chaotic. Suddenly—almost as if the ant has finally made up its mind what to do—it builds a highway. It repeatedly follows a sequence of precisely 104 steps that moves it two cells southwest, and continues this indefinitely, forming a diagonal band. This relatively simple large-scale feature emerges from the low-level rules. But there is more. In fact, computer experiments show that the ant always seems to end up building a highway, even if you scatter finitely many black squares around the grid before its starts—in any pattern whatsoever. But nobody has ever been able to prove that the ant always builds a highway. So here we have a high-level feature that seems to be universal, but which cannot currently be deduced form the Theory of Everything. It is striking that even on such a simple system as Langton’s ant, where we know the Theory of Everything because we set it up, nobody can answer one simple question: starting from an arbitrary ‘environment’ of finitely many black cells, does the ant always build a highway? So here the Theory of Everything lacks explanatory power. It predicts everything but explains nothing. Traditional science saw regularities in nature as a direct reflections of regular laws. That view is no longer tenable. Neither is the view that the universe rests on a single fundamental rule system. Instead, there are—and must be—rules at every level of description. The universe is a plurality of overlapping rules. And in the gaps between the rules lies Ant Country, in which simplicity and complexity not only fail to be conserved, but transmute into one another…The upshot is that as one goes “down” there is more and more, not less and less. Ant Country is a symbol for the gap between top-down reductionism and bottom-up reductionism. The explanatory story must enter the uncharted territory of Ant country. And that is where the emergent phenomena live, it is where they come from. Ant Country is where complexity is created from nothing, where systems organise themselves into more complex system without anything equally complex telling them how

> to do it. Until very recently hardly anybody would suggest that complexity need not 'come from' anywhere"[637]

Hardly anybody except Kropotkin who also though that there were no permanent laws in nature and that order or organisation was 'everywhere and nowhere'.

The Fallacy of Complexity:

Humans are self-conscious creatures that value complexity. However, bacteria were the only organisms for most of evolutionary history. There was no hurry or inevitable force behind complexification. Bacteria lie at the basis of all living systems and in terms of number and mass remain the most numerous. Some evolutionary thinkers talk in terms of the "fallacy of complexity".[638]

Life must start with small and simple forms and move towards increasing size and complexity by virtue of the fact that it is not physiologically possible nor selectively advantageous to be any smaller or less complex. Complexification, Gould suggests, may simply be the undirected filling up of spaces opened up by successively evolved walls of minimal complexity. Whether this process is "driven" or results from "passive" diffusion away from an impassable lower boundary of minimal size and complexity has been investigated and debated by palaeontologists:[639]

> "Large-scale evolutionary trends are persistent directional changes in higher taxa spanning significant periods of geological time; examples include the frequently

[637] Cohen J. and Stewart, I., *Simplicity in a Complex World*, Futures, 1994 Vol 26 #6 passim

[638] S. J. Gould, *Full House: The Spread of Excellence from Plato to Darwin*, New York, Harmony Books, 1996 page 19.

[639] McShea, D. W. *Evolutionary Change in the Morphological Complexity of the Mammalian Vertebral Column*. Evolution # 47 (1993), pages 730-40.

McShea, D. W. *Mechanisms of Large-Scale Evolutionary Trends*. Evolution # 48 (1994), pages 1747-63.

Boyajin, G., and Lutz, T. *Evolution of Biological Complexity and its Relation to Taxonomic Longevity in the Ammonodidea*. Geology 20 (1992), pages 983-86.

Stanley, S. M. *An Explanation for Cope's Rule*. Evolution 27 (1973), pages 1-26.

Gould., S. J. *Trends as Changes in Variance:A New Slant on Progress and Directionality in Evolution*. Journal of Palaeontology #62 (1988), pages 319-29.

> cited long-term trends in size, complexity, fitness in life. In a driven trend, the distribution mean increases on account of a force (which may manifest itself as a bias in the direction of change) that acts on lineages throughout the space in which diversification occurs. In a passive system, no pervasive force or bias exists the mean increases because change in one direction is blocked by a boundary, or other inhomogeneity, in some limited region of the space."[640]

Computer experiments and palaeontological data suggests to Gould that, there is no driving force toward complexity. By examining individual animal lineages that lie far from the lower boundary of minimal complexity, so that they can become more or less complex, it has been empirically shown that complexification and simplification are both equally likely. In a "driven" system, one would expect there to be a definite trend towards complexification. Complexity can be reversible, some animals succeed by remaining simple, others, such as parasites, have simplified in order to exploit specific micro-niches. Complexification rather than being the central thrust or cause of evolutionary development, might be an "incidental side consequence"[641]; a movement away from successive boundaries of minimal complexity. Fishes spinal columns (the most successful vertebrates in terms of the number of species) are simple and uniform and have not changed much since they evolved in the Devonian period. The evolution of greater complexity of the vertebrae in reptiles may have evolved because it was not selectively advantageous to become less complex. Although lower boundaries of minimal complexity cause the evolution of life to be skewed toward the evolution of complexity, it is suggested that there is no impelling force behind this. There is no "guarantee of long-term, monotonic, increasing trend. Mean and maximum complexity must passively decrease sometimes also."[642]

Complexity and Social Revolution:

[640] McShea, 1994, page 1747.

[641] S. J. Gould, *Full House: The Spread of Excellence From Plato to Darwin*, New York, Harmony Books, 1996, page 196.

[642] McShea, 1993, page 737.

There was nothing inevitable about our evolution. Humans, like all other species are an “unrepeatable particular.”[643] However, I believe the conclusion that complexification was a passive accident overlooks the active role of organisms. Multicellular life, which is a milestone in the development of complexity, was not imposed, but evolved by mutualism and co-operation. Free-living cells multiply rapidly. As Margulis remarks, they “contain the principle of social altruism, in which some cells specialised and curtailed their “selfish” tendency toward indefinite propagation for the “benefit” of the group to which they belong.”[644]

Life may have evolved to be completely anti-social, but it did not. Although we should not undervalue microscopical complexity the development of multicellularity, plant communities and animal societies are much more complex in quantitative and qualitative terms. Complexification occurred comparatively rapidly; in the last one sixth of evolutionary time. Although there was no compelling reason for complexity to develop, once, the dynamics of sociality and differentiation evolved, multicellular ‘unity in diversity’ took us from *Pikaia* (the world’s first known chordate with a notochord--the evolutionary precursor of the spinal column) to humans, in half a billion years. Prior to the Cambrian ‘explosion’, life, from the point of view of progressive complexification, had remained at a standstill. In my opinion, it was the dynamic fusion of differentiality and sociality, that powered this explosion. Even if evolution had stopped at fish, these are infinitely more complex than unicellular life. Although there was no necessity for reptiles, mammals and humans to have evolved from fish, the fact that they did so in such a relatively short geological period, points, in my opinion, to a driven rather than passive trend. If life had not socialised itself it is conceivable that multicellular life might still have

[643] S. J. Gould, *Full House*, page 4.
[644] Lynn Margulis, *Slanted Truths*, page 194.

developed, perhaps by hierarchical control/master-slave relationship with one cell controlling many others. I doubt that complexity could have evolved from these hypothetical entities. Top-down approaches to the development of complexity don't work very well bio-mathematically as we saw with the boids. Complex entities tend to arise by horizontal, social and federative networking not by a biological bureaucracy. It has already been shown how molecules or cells and the systems they generate are attracted or driven to dynamic near-chaotic conditions that seem particularly conducive to emergence and evolution. These states far from being top-down phenomenon are the product of states in which there is maximal interaction or information exchange between all of the molecules or cells in the system. It seems clear that complexity resulted not from the top downwards and from the outside inwards, but from sociality.

Mutualism and the Evolution of complexity:

Fox's non-living protocells, from which modern, cells may have gradually evolved, are social:

"Protocells display strong tendencies to associate and communicate. Individuals not only influence each other, they also associate in ways that constitute behaviour unpredictable from examining individuals alone."[645]

Although it is true that unicellular bacteria dominated life on Earth for most of its history. This does not mean that complexification was precluded. It has recently been discovered that, bacteria live in integrated groups called biofilms. Different bacteria producing particular wastes interact in socio-economic systems with other types of bacteria that specialise in utilising them. Bacterial bio-films build up a metabolic system in our gut allowing us to digest. Bacterial bio-films underlie

[645] Sidney Fox, *Proteinoid Experiments and Evolutionary Theory*, pages 25-6.

all ecosystems. They are a category of social living inbetween unicellular and multi-cellular life, "effectively enjoying a kind of multi-cellular life served by a circulatory system. They are metabolically active but non-proliferating, just like most of the cells in our body."[646] Multicellular evolution has resulted in unified social wholes composed of trillions of group-specialised co-operating cells with vastly enhanced, and indeed, realised possibilities, for large, novel emergent evolutionary complexification events such as the development of reptiles or the human brain. Kropotkin correctly believed that intelligence (one type of complexity) was largely a product of social life. It is constantly emphasised in *Mutual Aid* that sociality lies at the basis of all progressive (defined in terms of complexification) evolution.

Thermodynamics and Co-operative Complexification:

Genomic, cellular and ecosystem evolution emerged from symbiotic unions and mutualistic processes. The requirement to recycle or maximise (eg. group pooling its resources in hunting) available energy may even drive systems down these co-operative webs or pathways. The "thermodynamic rationale fuels parasitism and the elaboration of mutualistic networks" reduces the amount of expenditure necessary on metabolic and behavioural activities. The "evolution of mutualism allows for reliance of other organisms as part of their homeostatic functions."[647]

Non-Thermodynamic Perspectives on Complexification:

Entropy as we have just seen can be a creative source of life in an open system such as that of Earth. But, it is also associated with the 'heat death' conception of the universe that denies that life can ever escape the diffusion and dissipation of all energy in the universe. Challenges to this conception have come from bio-mathematicians such as Ho, Barbieri, Stewart and Cohen. Al these authors argue that

[646] Ho, *Genetic Engineering*, page 228.
[647] Wicken, *Evolution, Thermodynamics and Information,* pages 164-5.

life has transcended thermodynamic constraints and that, this can be seen in micro-level biochemical or cellular processes many of which appear to exhibit zero entroy. Barbieri, whilst not rejecting the importance of thermodynamics in the evolution of life, argues that his code based interpretation shows how life's emergence cannot be adequately explained by the information-energy-replication metaphors. More radical physics perspectives can be found in the works of Ho, Stewart and Cohen who reject the primacy of the entropy law in either the universe or biological nature. Stewart, Goodwin and Kauffman with their notions of phase space, adjacent possibilities and environmental context argue that biological evolution, contrary to Gould's ideas, is driven by a engine of diversification that leads directly to complexification. Stewart and Cohen further argue that the entropy law is not sacrosanct and that our universe is inherently self-complexifying:

> "Nearly all physicists today believe that life can only persist by increasing the entropy of its surroundings more than it decreases its own entropy. This model is not sacred. A very simlar, slightly more complicated model, that incorporates gravity affect the elastic balls in the system, shows a precisely opposite trajectory: It increases in order as time passes! In the real universe, this means that an initially hydrogen/helium filled cosmos amplifies any tiny heterogeneity into a gravitational anomaly around which grows a star, a galaxy, a cosmic order. Proponents of such a model are not surprised to find local increases of order, living things, not only fighting increasing entropy. In Stewart's new thermodynamic model instead of the underlying dynamic of our universe being the dissolution of order towards a Heat Death, it is instead committed to progressive increase of order, at least at the physical level. Life, as a complex system has lifted itself out of the simpler constraints of chemistry and physics; the mitochondrial proton pump workds as if heat engines, and entropy, were irrelevant to it."[648]

Barbieri similarly argues that biologically coded complexification processes are fundamentally different from chemical-thermodynamic self-ordering processes.

[648] Cohen J., *How Does Complexity Develop?*, Pages 6-7 &4.

> "Kauffman concludes that the university is inevitably progressive, constantly invading its adjacent possibilities. His evidence is that both biology and technology are continually expanding their phase spaces into "the adjacent possible" [649]

Symbiosis and the Evolution of Complexity:

Symbiosis lies at the origin of many complex ecosystems (coral reefs, most terrestrial forests, herbivory etc), specialised organs in individual species and major speciation/complexification events. The capacity for widely differing life forms to form co-operative relationships has been a major source of complexification and is far from a random or passive affair. In one textbook on symbiosis, the author introduces the chapter concerning the symbiotic evolution of structural novelty with the following summary:

"Some fish and squid bear luminous bacteria in *elaborate* light organs, associated with a *complex* of precisely aligned lenses and mirrors that control light emission. The root nodules of many legumes are *complex* plant organs, which usually develop only in response to compatible rhizobia. Some lichen thalli are among the most *complex structures* displayed by ascomycotine fungi."[650]

Most writers avoid using the same word in three consecutive sentences. The author had little choice as the morphological details of symbiotic adaptation in leiognathids and legumes are ingenious, creative and so very, very complex. Symbiosis was in the past often dismissed precisely because of structural complexity. These complexities were thought of more as biological curiosities as one-off freaks of nature; of little use in developing general biological theories. We now know that symbiotically generated complexity allowed for the development of plant phsotosynthesis and animals respiration, and lies at the basis coral reefs and, virtually all, terrestrial ecosystems.

[649] Cohen J., *How Does Complexity Develop?*, Page 3.
[650] Angela Douglas, *Symbiotic Interactions*, New York, Oxford University Press, 1994, page 40.

Fluid and Crystallised Order

Kropotkin using naturalistic biophysical premises claims that, society requires continuous change and adaptation:

"The life of society we understand, not as something completed and rigid, but as something never perfect, something ever striving for new forms in accordance with the needs of the time. This is what life is in nature."[651]

Centralised bureaucracies cannot adequately administer the diverse and ever-changing needs of society, particularly, in their local or regional aspects. Government attempts to impose static uniformity upon dynamic and ever-changing societies. Government is contrary to nature; restraining and sapping the vitality of a 'freely evolving' social system: "Instead of perpetual growth corresponding to that of the human race, we find law's trait to be immobility, a tendency to crystallise what should be modified day by day."[652] Anarchism envisages:

"A society to which pre-established forms, crystallised by law, are repugnant; which looks for harmony in an ever-changing and fugitive equilibrium between a multitude of varied forces and influences of every kind".[653]

Fluid, dynamic, non-equilibrium concepts are central to modern explanations of natural ordering processes in diverse phenomena, including genomes, immune systems and ecosystems.

Fluid, Dynamic Non-Symmetrical/Equilibrium Order

Whilst discussing the formation of new stars from nebulous clouds, Kropotkin concludes that, nebulae are "living" at a "rapid speed". "In the movements

[651] Kropotkin, *Modern Science and Anarchism*, abridged version in Baldwin op. cit. page 185.
[652] Kropotkin, Law and Authority, Revolutionary Pamphlets, page 200.
[653] Kropotkin, Law and Authority, reprinted in Baldwin op. cit., page 200.

of these remote agglomerations we observe “Nature’s continuous change, its evolution.”[654]

Earth’s natural processes cannot be represented as static and unchangeable. Life is an ongoing adaptation to the ever-modified needs and requirements of continual evolutionary change:

> “Ideas of stability hitherto attached to everything in nature, is broken down, destroyed and put to naught! Everything changes in nature, everything is incessantly modified: systems, wages, planets, climates, varieties of plants and animals, the human species—Why should human institutions perpetuate themselves! Nothing remains, everything modifies itself, from the rock which appears immovable and the continent which we call “terra firma”, to the inhabitants, their manners, their customs, their ideas. What we see around us is only a passing phenomenon that ought to modify itself, because immobility would be death. These are the conceptions to which modern science accustoms us.”[655]

Ideas of constant stability dominated scientific thinking in diverse fields (e.g. ecology, genetics and biogeochemistry), until the 1970’s. In contrast, Kropotkin, work upon dynamical geology and climate change embraced fluidity.

In ecology, landscapes were conceived as reaching climax or mature states that, without disturbance, would remain unchanged indefinitely. Fires were rigorously repressed in forests requiring them. The belief in permanent mature natural states resulted in management practices that caused an unnatural build-up of combustible material leading to catastrophic fires of much greater intensity. Controlled burning has now becoming the dominant practice in forests adapted to fire. Conservation ecologists realise that it is necessary to anticipate change or replicate the effects of natural disturbance processes in management practices.

[654] Kropotkin, *Spectral Analyses of Stars*, Nineteenth Century, vol. 31, 1892, page 444.
[655] Kropotkin, *Revolutionary Studies*, Section III, The Commonweal, London, 2 January 1892, page 2.

Genetics was dominated by static, additive, micro-mutational concepts until the discovery of the 'fluid' genome around 1970.

It was once believed that the biosphere was extremely stable. Pioneering biogeochemists thought that, biospheric self-regulating mechanisms would compensate for increasing carbon dioxide emissions. This might have been true over geologic time, but, we now know that the atmospheric and climatic conditions to which we are accustomed cannot be taken for granted.

Energy Flow and Fluidity:

Life is informed fluidity and evolved through matter forming systems internally utilising energy and matter flows. Life then created information systems able to replicate their systems. "Living systems are processes rather than things, and their existences are contingent on steady throughputs of matter and energy. More precisely, living systems are processes *composed* of things."[656] The "emergence of living systems occurred through the gradual acquisition of structural information for mediating thermodynamic flows."[657] "Thermodynamics is about process not static elements."[658] "The golden braid of evolution is not woven from static structures but from process and information".[659]

Energy flow makes life probable. Life is the product and organiser of a flow of photon energy integrated with material or chemical processes. Life by storing, transforming and manipulating matter-energy flows, is able to "engage in extremely

[656] Wicken, *Evolution, Thermodynamics and Information,* page 70.
[657] Ibid, page 116.
[658] Ibid, page 10.
[659] Ibid, page 117.

rapid and efficient energy transduction and to summon stored energy at will"[660], as well as radically transform its living environment:

> "The space-time structure of living organisms arises as the consequence of energy flow, and is reminiscent of the non-equilibrium phase transitions that can take place in physicochemical systems far from thermodynamic equlibrium. Energy flow organizes and structures the system in such a way as to reinforce the energy flow"[661]
>
> "Organisms are dissipative structures in that their organization is maintained in some kind of 'steady state' by a flow of energy and chemicals"[662]
>
> "The living cell has a very large amount of energy stored in covalent bonds as electronic bond energies—considerably more than the thermal energies which exist in the equilibrium state. So large that, the probability of getting there by chance fluctuation around the equilibrium is essentially nil. So how come there are living organisms at all? The answer is energy flow. Energy flow greatly increases the probability of life, and is absolutely essential for its maintenance and organisation. Accompanying this energy flow is a cycling of materials through the biosphere: carbon dioxide, water, nitrogen, sulphates and phosphates are fixed by green plants and bacteria into high electronic energy compounds which cycle through the bodies of animals in the biosphere before they are broken down and returned to the soil."[663]
>
> "life depends on catching an excited electron quite precisely—by means of specific light absorbing pigments—and then tapping of its energy as it falls back towards the ground state. Life uses the highest grade of energy, the packet or quantum size sufficient to cause specific motion of electrons in the outer orbitals of molecules. It is on account of this that living systems can populate their high energy levels without heating up the body excessively…But what enables living systems to do so? It is none other that their meticulous space-time organization in which energy is stored in a range of times scales and spatial extents…energy flow organizes the system which in turn organizes the energy flow. Stored energy is the organization, which is what enables the living system to work so efficiently on a range of timescales"[664]

Living organisms are dependant upon critical levels of complexity generated by the ability of a dynamic system to thrive at a transition point of complex dynamic

[660] Ho, Mae-Wan, *The Rainbow and the Worm: The Physics of Organisms*, Singapore, World Scientific, 1993, page 10.
[661] Ibid, page VII.
[662] Ibid, page 21.
[663] Ho, Mae-Wan, *The Rainbow and the Worm: The Physics of Organisms*, page 34.
[664] Ibid, page 70.

order and chaos. Life exists between fixed, static or crystallographic order and disorder. When conditions are slow life tends to crystallise like ice, into a uniform, static and unchanging order. Simple, static and fixed, non-dynamic equilibrium configurations are lifeless.

> "Crystallographic order is due to its equilibrium character. Elements arrange themselves according to the principle of free energy minimisation. Organic order, in contrast, is remote from equilibrium and requires constant dissipative activity to maintain it".[665]

At the other extreme conditions are completely chaotic like boiling water bubbling away chaotically. Living, utilisable configurations of molecules, exist upon the threshold of disorder: "Life is not a property of matter but the dynamic self organisation of that matter. Its operating principles are the laws of dynamic form, independent of the details of a particular carbon-based chemistry that arose on Earth."[666]

Fluidity of Bacteria:

Bacteria rapidly adapt to exploit new food sources/unwelcome pollutants as well as protect themselves from human antibiotics through exchanging DNA.

Bacteria are genetically promiscuous. When faced with antibiotics or pollutants they form groups and, swap DNA among themselves by means of tube-like structures, thereby, gaining resistance or utilising the pollutant as food. During these exchanges natural genetic parasites are also able to travel. Sometimes these are able to recombine with pro-viruses. Viruses able to interact with genetic parasites already attached to the genome. Bacteria also emit pods containing DNA utilisable by other bacteria. Bacteria and other mobile genetic agents also incorporate into their

[665] Wicken, *Evolution, Thermodynamics and Information,* page 50.
[666] *Complexity*, page 227.

genomes DNA from decaying cells in the environment. Horizontal gene transfer in microbial populations is a major mechanism for the spread of antibiotic resistance.

The Fluid Genome:

The supposed dichotomy between genetic and behavioural transmission is false. When the genome repairs itself after viral attack or an environmentally induced transposition event; or, when an insect genome amplifies those genes responsible for detoxification following human insecticide attack; the genes are *behaving* in a characteristic way. Genetic change was once seen as slow and static, and behaviour as fast or immediate. Because amplification and transposition events can result in chromosomal incompatibility and heterochronic (developmental timing) changes, they may cause exceedingly rapid speciation. Human skulls are remarkably similar to those of the ape foetus. It is currently considered most likely that humans evolved from heterochronic mutations affecting developmental timing in early embryogenesis.

"The belief in the constancy and fixity of genes substituted for the belief in an immortal soul when science replaced religion."[667] This idea is premised upon nature being fixed and static. However:

> "The application of new molecular techniques reveals that, beneath the level of the chromosome, the genome is a continuously changing population of sequences. Mobility, amplification, deletion, inversion, exchange and conversion of sequences create this unexpected fluidity on both an evolutionary and developmental time scale."[668]
>
> We must reject the: "family heirloom conception of heredity in which something is transmitted unchanged…there is almost nothing that remains static and unchanging. Organisms are life histories and not mechanical objects…Whereas the stability of mechanical objects depends on static equilibrium, organisms are *dynamically maintained*, and utterly dependent on

[667] Ho, *Genetic Engineering*, page 58.

[668] Dover, G. A. and Flavell, R. B., (eds.) *Genome Evolution*, Academic Press, London, 1982, blurb on back cover.

> activity; in other worlds, on fluidity and change. The cessation of activity spells death. Heredity—a name give to the observed constancy of reproduction—must ultimately be looked at as a process, and not as some *material* which is passed on from parent to offspring"[669]

The development of an organism is a complex, decentralised, federalist and interactive process, in which causation and information is delocalised within a multi-dimensional, non-linear, super network. Even in the mature organism the genome is living and constantly changing, just like everything else in nature:

Gene expression states are heritable quite independently of changes in DNA. It is not simply what material is contained in the genome but how and whether it is expressed. Genes may be turned on or off (silencing), multiplied many, many times over (amplification), or jump from one part of the genome to another (transposition). Although the DNA is unchanged it is expressed differently. These differences can get passed on to the next generation, a process known as epigenetic inheritance. The genome has a ready-made tool box which springs into action during viral attacks and environmental challenges. It is part of the flexible or fluid response of the genome to an ever-changing environment.

The importance of these flexible and environmentally responsive mechanisms is seen in insect resistance. When exposed to a sub-lethal chemical dose the genes encoding enzymes that detoxify the chemical or increase the rate at which toxins are pumped out of the cell, are *amplified* many times over.

Fluidity of Organic Codes and Conventions:

Conventions in human society form an interesting area of social and linguistic inquiry. Conventions are without the rigidity of customs and legislation and are typically flexible day-today rules of thumb that can be changed almost instantly

[669] Ho, *On Not Holding Nature Still: Evolution by Process, Not by Consequence*, pages 131 and 136.

when needed, but, may also be as permanent and timeless as custom if they continue to be socially useful. Barbieri discusses at length the difference between biological and cultural determinism and the stable, but flexible world of biological and cultural conventions of which coding and language are the most relevant. He looks at the flexible and interpretive world of splicing codes and signal transduction codes in comparison with other epigenetic process resulting from the simple action of catalysts. Organic codes are, he concludes, flexible conventions:

> "*All events of epigenesis are processes of assembly*"
> "In living systems assemblies usually require catalysts. But, in some case catalysts are not enough. An example is protein sysnthesis. Amino acids are assembled into polypeptides, but a catalyst is not enough to determine the order of the units which requires a code-bases set of adaptors."
> "We must distinguish between two different types of epigenetic processes: *catalysed assembly* and *codified assembly*" "Mitochondria and some micro-organisms have codes which differ from the universal one, which shows there is no necessary link between anticodons and amino acids. The codon recognition site is independent form the amino acid recognition site."
>
> Splicing involves two process, removing the introns and "assembling the remaining pieces into messages" to form exons. The first "cut and paste" process "would require only a catalyst", but, the second process appears to require a "set of adaptors comparable to ribosome and tRNAs." [670] "Whilst the genetic code is practically universal, in the case of splicing there are a plurality of codes as there can be different sets of rules in different organisms." (105) In the case of signal transduction codes "there are literally hundreds of first messengers whereas the known second messengers are only four. First and second messengers belong to two independent worlds suggesting that signal transduction is likely to require the intervention of organic codes."[671]
> There is also the extra ordinary operation capabilities of the cell cytoskelleton "which biologists have decide to call dynamic instability". The cytoskelleton that provides cell motility through dynami instability is able build structures with an "exploratory strategy" allowing for almost "unlimited" morphological

[670] Barbieri M., *The Organic Codes*, Cambridge University Press, 2003, pages 98-101
[671] Barbieri M., *The Organic Codes*, pages 105-7

diversity. Barbieri claims that this is achieved through "cytoskelleton codes and conventions."[672]

"Environmental signals can be decoded in many different way and what reached the genes is only the final result of an extremely complex decoding procedure. Different signals can produce equal results. Outside signals do not have instructive effects. Cells use them to interpret the world, not yield to it." "The multi-functionality of many molecules means that their function is not decided by their structure but by the environment and context. In every day (human) life a message does not carry only grammatical information, but also information which is called implicit, or contextual, because it is determined by the context of the message. "The cell doesn't only transmit signals but is a system which manipulates and integrates them in many different ways. And it is precisely this ability that explains why a limited number of second messengers can generate an extraordinary number of outcomes and end up which specific effects on genes."[673]

Fluidity or Dynamism of Animal Behaviour:

Kropotkin, considering experiments upon amoeba and larger marine invertebrates concludes that, the most primitive organisms are discerning about their environment and diet. Unpleasant and enjoyable meals are 'remembered' by the organism. Subsequent identical meals were avoided or consumed according to previous experiences. Marine invertebrates when tested for their reactions to warmth, light, narcotics, electricity etc., reveals that, lowly organisms exhibit: "descriminative powers" involving "choice", "memory", "free-will" and "some rudiments of reasoning." The brain and the nervous system, Kropotkin asserts, developed as an "unbroken continuum" from the sense and behavioural capacities of bacteria.[674]

There has been strong selective pressure to develop quick, flexible, fluid, non-genetic responses to the environment. Flexible behavioural responses may always have been an integral component of what is inherited by the next generation, in virtue of the fact that: "transmission of information by the egg cytoplasm to the

[672] Barbieri M., *The Organic Codes*, pages 179-80
[673] Barbieri M., *The Organic Codes*, pages 109-12
[674] Kropotkin, Senses of Lower Organisms, *Recent Science*, *Nineteenth Century*, Aug. 1896.

new developing embryo is an intermediate condition between direct gene transmission and behavioural transmission."[675]

The development of social life and motility in animals has also resulted in the development of large brains and sophisticated senses. The ability of animals to teach themselves by trial and error and imitation and, in social insects and higher animals to learn, instruct or teach is, the result of strong selective pressures for flexible or fluid responses to the environment that, can be immediately learnt or socially inherited by others. The evolution of superior vision and visual gestures allows for inventive solutions that can be learnt by other members of the group through simple imitation "at the speed of light"[676]. Despite the limitations of compound eyes, bees, through dancing, are able to visually communicate information regarding the direction of food. Environmental and geographic information, regarding the location of food, new predators etc., is impossible to encode genetically, as the environment is constantly changing. Flexible behavioural responses has led to a "progressive shift of information transfer by the genome to transfer by the brain"[677] Mice and human genomes are of similar size. Although genetic differences in brain size are important, social and cultural evolution in the higher mammals "has not been achieved by accumulating genes". [678] *Mutual Aid* stresses the importance of social interaction and communication to the development of intelligence and culture. Kropotkin thought, individuals, groups and species increased survival chances through transmitting learnt changes in diet or behaviour.

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[675] Bonner, Ibid, page 167.
[676] Bonner, J. T., *The Evolution of Culture in Animals*, page 110.
[677] Bonner, page 115.
[678] Bateson, P., *The Active Role of Behaviour in Evolution*, in Ho and Fox (eds) *Evolutionary Processes and Metaphors*, page 201.

Genomes would have to be the size of houses to carry information able to address every possible situation. Behavioural plasticity compensates for this. An animal that can change its behaviour overnight and pass it onto their offspring or group may well hit upon a new behavioural strategy that vastly increases survival in challenging environments. "The highest form of flexibility is invention where new choices are opened up where they did not exist previously…flexible responses allow creatures to invade new habitats or new sources of food—this kind of flexibility needed for macro-evolutionary progress as new niches will in turn produce new and different selective forces"[679]

Fluidity or Dynamism of Ecosystem:

Ecosystems are autocatalytic systems elaborated and maintained through a constant flow of energy. Ecosystems are subject to continual disturbances varying greatly in location, periodicity, magnitude and severity leading to the creation of heterogeneous landscapes. Over geological time-scales, climatic and other fluctuations mean that the location and composition of ecosystems change continuously.[680] Australia's Barrier Reef did not begin to form until the rise of sea waters after the ice-ages 12, 000 years ago. It did not assume its present form until 6-7, 000 years ago. The coral cays, composed of banked-up coral rather than submerged continental mountain peaks, are only a few thousand years old.

Palaeo-ecology reveals that nature is not constant. There were many ice ages and interglacial periods and their effects were felt in all latitudes. Examination of pollen from lake sediments has revealed that, plant species migrated to a wide variety of different locations at different times and at different rates, such that ecosystems

[679] Bonner, J. T., *The Evolution of Culture in Animals*, pages 165 and 153.
[680] Botkin, D., *Discordant Harmonies: A New Ecology for the Twenty-First Century*, Oxford Uni Press 1990, pages 56-66.

often did not include the same species. Studies of forests in Australia have shown that the species composition of rain forest ecosystems and their location across the landscape have varied enormously over the last 30, 000 years.[681]

Fluidity or Dynamism of Atmosphere and Biosphere:

Mars and Venus formed at the same time as Earth with relatively similar orbits and initial chemistry. But, they are chemically inert, the majority of chemical reactions having been "spent", in accordance with the laws of physics and inorganic or equilibrium chemistry. Their atmospheres comprise of carbon dioxide and small percentages of nitrogen, oxygen and water. Earth's atmosphere is mainly nitrogen, 1 fifth oxygen and about 1% carbon dioxide. This is a dynamic and highly reactive combination of gases that cannot be accounted for by the laws of equilibrium chemistry and physics. The laws of inorganic chemistry were successfully utilised by life to biochemically create an atmosphere conducive to the needs of life itself. The processes and manipulations employed by life has created a biosphere in which the atmosphere is integral to the living state. Earth's atmosphere, despite remaining stable for millions of years, not only defies the laws of equilibrium but, is itself in a state of profound volatility. An order that is stable, but in a state of volatile disequilibria.

The *recycling* of Earth's elements are living fluid processes. Nitrogen is recycled in a "period of about a million years" and oxygen once every thousand."[682] Staggeringly fast in geologic time. Astrobiologists are continually discovering new biogenic gases with potentially important functions in the global ecosystem. Over evolutionary time life has transformed the geology of the planet by bio-geo-chemical processes. Bio-chemical-dynamics and geo-dynamics cannot be easily separated. It is

[681] Ibid, pages 56-66.
[682] *Gaia in Action*, Peter Bunyard (ed), page 304.

only because of water that molten magma becomes Granite. Similarly, we must appreciate the role of “biota in transforming geology”. By “dramatically speeding up of weathering biotic activity is comparable to mining”. Limestone created by shells may be a significant cause of volcanic activity, literally feeding volcanoes:

“Ultimately, the used end-products of the biota are dumped on the deep-sea floor and enclosed in the slowly accumulating sediments. Sea-floor spreading will bring the refuse to a deep-sea trough where it is subducted. The sedimentary mass is subjected to high temperatures and pressures and pushed up during the formation of a mountain ridge. Thus it is made available as raw material for a new cycle. Not only does plate tectonics serve as a sewage system for life, it is also responsible for the generation of fresh nutrients from the fluxes of refuse…Biochemistry is a constituent part of geochemistry”[683]

Homeostasis and Homeorhesis:

Homeostasis is maintained by *static* or cyclical fluidity that is incapable of adaptation. Homeostasis is akin to mechanical turns of the wheel or a thermostatically controlled refrigeration system. Life has continued to evolve despite catastrophes and ongoing external or universal pressures.

The term homeorhesis is used by scientists to describe fluid and potentially adaptive biological systems in contrast to machines and individual organisms. Cybernetic or homeostatic systems, in contrast to homeorhetic ones have, an externally controlled fixed point, such as a thermostat, which is conceptually similar to homeostasis in organisms where the temperature of the body is precisely controlled internally.

Homeostasis, Homorhesis, and the Evolution of the Biosphere:

[683] Westbroek P.,and Jan de Bruyn G., *The Geological Impact of Life*, in *Gaia in Action*, Peter Bunyard (ed) UK, Floris Books, 1996, pages 105-14.

Living systems must respond to internally generated changes (e.g. the creation of globally significant quantities of oxygen produced by newly evolved anaerobic bacteria 2200 million years ago) and externally inflicted catastrophes (meteor impacts), as well as potentially catastrophic ongoing tendencies (increasing solar luminosity over past 4 billion years). Homeostatic processes cannot provide the required evolutionary element necessary to survive in a changing, and sometimes dramatically changing world/universe. Although homeostasis might appear to characterise much of evolutionary time the goal posts and the rules of survival have changed dramatically. Homeostasis results in death. Adaptive fluidity provides a chance for further life.

Homeostasis and Homeorhesis and Embryological Development:

Epigenisis similarly is similarly a flexible process. Cohen drawing upon pioneering thinkers as C. H. Waddington describes homeorehtic nature of the epigenetic landscape in terms of the "metaphor" of a car route:

> "Embryological development does not result in mantainence but in progression…We like car routes on landscapes, which demonstrate homeorhesis: we went wrong three junctions ago, but we can take a left at the next lights, turn right at the third crossroads and that will bring us back to….”; a whole journey with its possible by-roads and corrections, is like a development."[684]

In this unpacking of the metaphor the driver is an active conscious agent in the decision. In another unpacking of the path, route, etc., again drawing upon Wadington, Cohen describes how the epigenetic landscape can create novelty because of the interaction of the developing individual with unique environments:

> "as the parts of an embryo run down the bottoms of their notional valleys like rivers: and if by chance or flood the course of development runs up the side of a

[684] Cohen J., *Becoming Maureen—A Study of Development*, page 51

> hill it never comes back to where it was, it runs down the valley further toward the sea[685]"

Similarly when the motorist encounters a fallen tree he might take another route altogether and arrive at a comparable destination. When these subtle changes and recombination are "canalized" for one reason or another new species may result[686]

Cohen drawing upon Goodwin's work criticizes Dawkins' naively static and preformist developmental metaphors:

> "Goodwin has attempted to fit developmental paths in the phase space of possible sequels to eggs, constraining them by geometry on the one hand and the smallish repertory of proteins form DNA of the other. The successive stages exist in new sets of rules, so that "the same DNA make protein can have quite different effects later, in a wing bud for example, in contrast to segment formation in the early embryo. The phase space of possible effects of transcripition of any gene is dependent upon which place, and at which stage it happens. In this kind of vision of development there is therefore, in principle no mapping from a particular gene to some structure in the final stages of the organism. This kind of metaphor for development contrasts with that of Dawkins, whose "gene for a nose", or for a wing or a hand, draws the reader to suppose that the DNA genome is, in some sense, the pattern for the later animal. Such a "blueprint" model, like all pre-formationist explanations of development , is intellectually lazy. Some few embryologies (e.g. nematodes and a few plants) do seem to have nearly blueprint development, but nearly all complex organism have interactive homeorhetic development whose trajectory changes the developmental rules as it proceeds. This kind of complicity between the genome and environment, including its read-out mechanism, precludes mapping from genome to character."[687]

Homeostasis, Homeorhesis, and Ecosystem Succession:

Kropotkin, through his pioneering geological work upon climate change appreciated, more than any of his contemporaries, the fluidity, dynamism and unpredictable nature of living systems. He was never sympathetic to organismic

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[685] Cohen J., *Becoming Maureen—A Study of Development*, page 52-3
[686] Cohen J., *The Evolution of Complexity*, page 354
[687] Cohen J., *Becoming Maureen—A Study of Development*, page 53

descriptions of the natural world and his characterisations of stability are made in terms of precarious, temporary, volatile compromises, rather than, some predictable process leading toward one inevitable and stable natural balance. This contrasts strongly with other early ecological thinkers, most notably Clements and Marsh.

Although Clementsian ecology was dynamic and process orientated, nature was seen in deterministic terms; as being driven to a single natural equilibrium state. In the absence of disturbance an equilibrium or climax would continue indefinitely. Ideas of "equilibrium" and "climax" have fallen out of favour with the rise of non-equilibrium ecological perspectives. Even in systems that do tend towards equilibrium, there are often "multiple equilibria" (polyclimax). "Ecological responses to environmental gradients" are often 'history dependent'. Special climatic conditions at the time of the disturbance, may allow Beech forest to establish itself in an area where it would be expected to find Populars. Disturbance and succession cause landscape heterogeneity. Ecosystems exist in dispersed 'patches' because of the unique history of every disturbance. Even "the shape and orientation of forest openings, as well as their size, can be important in determining their microclimate."[688] The patchiness and diversity of landscape types maximises species diversity. Non-equilibrium ecology looks at phenomena such as, "erratic or chaotic systems particularly with regard to population oscillations".[689]

Studies of glaciation and recolonisation reveal continual geological and climatic changes and great variation in ecosystem composition and location over periods of less than a 1000 years. "Nature is constant and nature is not constant".[690]

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[688] Pickett S., and White P., (eds.), *The Ecology of Natural Disturbance and Patch Dynamics*, Academic Press, 1985, page 20.

[689] Naaiman, R, and Decamps H., *The Ecology and Management of Aquatic-Terrestrial Ecotones*, New Jersey, 1990, page 32-3.

[690] Botkin, D., *Discordant Harmonies: A New Ecology for the Twenty-First Century*, page 120.

Stability in nature tends to be associated with the age and size of the system. To the benefit of the whole millions of individual cells die in everybody everyday. Web sites disappear and large parts of the network may go down but, the internet still functions. Ecologists and biologists often characterise increasing stability in terms of hierarchical constraint:

> "higher levels in the life system's hierarchy, such as landscapes, biomes, and the biosphere, are levels involving interaction of an increasing number and variety of ecosystems…Each level in the ecological hierarchy influences what goes on at adjacent levels. Processes at lower levels are often constrained in some way by those at higher levels. For example, "a parasite and its host frequently engage in an oscillating arms race…But operating within the larger system over the long term, parasites and hosts, as well as predators and prey, tend to adjust to one another to achieve some sort of balance coexistence. In other words, large systems tend to be less changeable than the smaller component ones"[691]

Although individuals, populations, ecosystems and biomes come and go, at the level of the biosphere local chaos or temporary disturbance, even when it has far-reaching implications for life upon Earth, doesn't threaten the global super system. This is why the balance of atmospheric gases has remained stable for aeons. Global warming may severely impact upon human goals but it will hardly effect the biospheres ability to maintain life. Global warming shows that, "there is no such thing as a central control device that keeps nature as a whole in equilibrium."[692] Kropotkin states:

> "Nothing preconceived in what we call harmony in Nature. The chance of collisions and encounters has sufficed to establish it. Such a phenomenon will last for centuries because the adaptation, the equilibrium it represents has taken centuries to be established; while such another will last but an instant if that form of momentary equilibrium was born in an instant…Harmony thus appears as a temporary adjustment established among all forces acting upon a given spot—a provisory adaptation. And that adjustment will only last under one

691 Odum, E., *Ecological Vignettes*, pages 23-4.
692 Odum, E., *Ecological Vignettes*, page 27.

condition: that of being continually modified; of representing every moment the resultant of all conflicting actions."[693]

Computer Modelling of Homorhetic Self-Regulation:

It has been shown by means of computer modelling that fluid and adaptive self regulation and change need not be complex. 'Daisyworld' is a cyber planet with a simple atmosphere and large oceans of the same size and distance from the Sun as Earth and covered with daisies that are either black or white. Life is only possible between 5 and 40 degrees centigrade. As the sun expands Daisy world thaws and black daisies develop that absorb and store heat. With the continual expansion of the sun Daisyworld becomes steadily warmer until the temperature passes the optimum and white daisies evolve that reflect sunlight. Increasing solar luminosity eventually leads to the domination and replacement by white dasies. Daisies maintain the optimum temperature level of about 20 degrees centigrade over billions of years. As Daisyworld's sun expands temperatures eventually rise above 40 degrees, when, all life, according to the parameters of the model, cease.[694] Above 20 degrees, white daisies have selective advantage and below this temperature black daisies have competitive advantage.

Although, this model is reductive, only examining the possibility of homeorrhetically achieved thermostasis, it demonstrates how adaptive and fluid self-regulation could work to ensure the preservation of optimal living conditions through deep-time.

The notion of feedback systems has, bothered some scientists, who reject the idea of simple organisms (remember that bacteria are largely responsible for the

[693] Kropotkin, *Anarchism It's Philosophy and Ideal*, Revolutionary Pamphlets, pages 120-1.

[694] James E Lovelock, *Gaia: What's New*? (1983), published in Margulis, L., and Olendzenski, L. *Environmental Evolution: Effects of the Origin of Life on Planet Earth*, MIT press, 1992, pages 316-21.

creation and maintenance of the atmosphere) being able to assess environmental data and actively change their evolution. Surely shells did not start growing because animals sensed too much carbon-dioxide?! Rather, it was because the carbon reacted with other chemicals in their environment to form molecules that proved to be useful building materials. However, global environmental change in respect to gas composition, alkalinity and temperature over evolutionary time strongly suggests that the bacterial component has acted in a responsive way. But we have no clear idea of how the feed back mechanisms work, if they exist at all. We do not know what it is like to *be* a bacterium and never will. We only observe the results: The maintenance of a stable life-optimal biosphere for two billion years in the face of all kinds of inconveniences:

> "The radical insight delivered by Daisy World is that global homeorrhesis is possible without the introduction of any but well-known tenets of biology. The system does not have to plan in advance or be foresighted in any way in order to show homeorrhetic tendencies. A biological system acting cybernetically gives the impression of teleology. If only the results and not the feedback processes were stated, it would look as if the organisms had conspired to ensure their own survival."[695]

The very fact of extinction shows us that homorhesis is not kind to individual lineages or the specific details of life, But rather fluid systems and the ability for adaptive change has continually ensured the continuance and evolution of life. Fluidity allows for active (though not directed) modulation. Life is living, it is not a passive or inert phenomena.

Although certain aspects of homeorhesis might be explainable in terms of simple models like that of daisyworld the study of homeorhetic processes in large complex systems involving hundreds or thousands of negative and positive feed back loops is in my opinion a whole new area of science yet to be identified and investigated

[695] Lynn Margulis, *Slanted Truths*, page 151.

involving a whole new volcabulary in an effort to articulate how systems and organism respond to various challenges.

Diversity and Uniformity

Kropotkin believed that anarcho-federalist society, no longer subject to the centralised uniformalisation of the state, would through decentralisation and the formation of local independence, create a richer, more various and sustainable cultural and environmental mosaic.

Kropotkin suggests in the preface to *Fields, Factories and Workshops* that anarchism envisages a diversity of physical and society environments, and that, this would correspond, parallel and further two major and complementary evolutionary trends: "differentiation" and "integration". The organisation of life 'from the bottom upwards', "according to the infinitely varied and ever-changing needs of each locality"[696] would create a society more "integrated" with regional social and ecological variation; allowing for a more balanced and environmentally sustainable relationship with the natural world.

The importance of variety and diversity in maintaining the stability, productivity and survival of ecosystems is a topic that is explained in all elementary ecological textbooks.[697] The decline in biodiversity both regionally and globally is a pivotal concern of contemporary ecology and environmental activism.

Evolution, Kropotkin claimed, was not comparable to a "rolling ball" or "marching column"[698] with a single or overriding direction, but was better characterised as a multi-faceted development resulting a variety of diverse and often

[696] Kropotkin, *Anarchism: Its Philosophy and Ideal*, page 133.
[697] For example, Odum, E., *Ecology and Our Endangered Life-Support System*, pages 50-60.
[698] *Anarchism: Its Philosophy and Ideal*, page 142.

conflicting tendencies. The evolution of life was not the product of a small set of unalterable evolutionary laws or mechanisms, but, an ongoing and probabilistic process involving uniqueness, spontaneity and irreversibility.

Social and biological variation has allowed for evolutionary change, novelty and adaptation; to the development of new species, ideas and ways of surviving in a constantly changing and uncertain world. Without variation and change society and nature became static, immobile and lifeless. “Variety”, exclaims Kropotkin, “conflict even, is life, uniformity is death”.[699]

The stress which Kropotkin places on variation and diversification in nature, is, again, entirely consistent with our modern conceptions of natural process. The well-documented problems associated with agricultural monoculture are easily understood by most people, whilst beautifully produced, and increasingly popular wildlife films continually underline the evolutionary importance of the ‘variation’ and ‘adaptation’ of the individual, group or the ‘species’ to diverse, unique and often changing environments. “Life comes from differentiation rather than piecemeal assembly”[700]

Diversity and Palaeontology:

Cladogenesis or ‘speciation by branching’ has been a pervasive feature of evolution. Gould usefully illustrates this fact by examining the “full house” of horse evolution. Traditionally, the Horse has been depicted as the end product of evolution. It must have survived because it was better than the others; when, in actual fact, the horse survived only in Eurasia and became extinct in North America where it first evolved. Throughout the evolution of the horse there was a “steady state diversity pattern of extinction matching speciation” in which there was “no mainline of

[699] Ibid, page 143.
[700] Wicken, *Evolution, Thermodynamics and Information,* page 81.

evolution"; "no central thrust amid the diversity". The "full house of the equine bush" is typified by "copious branching bushiness". "None of the roots of the modern horse is straight" but, is characterised by "numerous labyrinthine paths". This notion of "bushiness versus linearity" or the "side-step versus the lockstep"[701], that is, "variation" or "change" of "entire systems"[702], is gradually replacing the upward eliminative evolutionary trees which used to illustrate biology texts.

What drives variation is what drives speciation and complexification. These causes, like their results are many and various: Symbiosis, mutualism, thermodynamic constraints, genetic mutation, neoteny, geological isolation, massive ecological interruptions, competition, etc., are all causes of variation or diversification. It seems clear that each diversification event would result from the interaction of a unique assemblage of contextual constraints.

Although the role of competition has not been emphasised in this series of articles, it is also "important in determining the number and kinds of organisms to be found in a given habitat or community." [703] But, there seems no doubt that the importance of competitive exclusion has been exaggerated. The widespread rejection of sympatric speciation (speciation without prior isolation) until quite recently meant that evolutionary thinkers had to account for species diversity in terms of isolation and fierce competition. Moreover, supporters of sympatric speciation have frequently argued that fierce intra-specific competition is a probable major cause that forces animals to invade new environments or utilise an under exploited niche.

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[701] S. J. Gould, *Full House: The Spread of Excellence from Plato to Darwin*, New York, Harmony Books, 1996, pages 63-69.

[702] S. J. Gould, *Full House*, page 15 and 153.

[703] Odum, E., *Ecology and Our Endangered Life-Support System*, Mass, Sinauer, 1993, pages 167-9.

In some cases, closely related species are able to coexist due to differing specialisations, but in other instances one species will always exclude another. For example, experiments with small beetles reveal that competitive exclusion occurs along a temperature gradient. Those species adapted to higher, lower, wetter, etc., conditions always ended up completely excluding the less well adapted species. In such examples, however, the use of the word competition is misleading. For, it is not at all the case that the better adapted beetles fight over resources or actively exclude less fit ones. Nor, moreover, is there any evidence that the variously adapted beetles

evolved as a result of competitive speciation. Perhaps though, the most compelling reason for questioning the orthodox position that competition is the overriding cause of diversity, is that, the co-existence of many (often similar) species sharing the same resource, is a common feature of ecosystems. Closely related species through "exploiting the same resource at different times or places" are able to coexist in the same environment. For example closely related seabirds might specialise in fishing at different depths even though they are feeding upon the same species of fish. "One reviewer of competition theory, den Boer (1986), concludes that, coexistence is the rule and complete competitive exclusion the exception in the open systems of nature"[704]

Competition, even when it is fierce and aggressive, rather than excluding different species often leads to dynamic forms of coexistence. Upon Jamaican coral reefs the corals are remarkably aggressive and ingest competitors by mesenterial filaments through temporary openings in their polyp walls. The slower growing massive corals that dominate deeper water with less light are the most aggressive. Thus the "aggressive hierarchy associated with extracoelenteric digestion promotes

[704] Odum, E., *Ecology and Our Endangered Life-Support System*, Mass, Sinauer, 1993, page 170.

coexistence by allowing the slower-growing, massive species to protect themselves from overgrowth by the more rapidly expanding branching and foliose corals."[705]

There have been many suggestion put forward in an attempt to explain species diversity. Another suggested source of speciation is paedogenesis, one form of which is neoteny. This is where juvenile features are retained into adulthood leading to complex and dramatic speciation events. There is strong evidence that humans evolved by this process.[706] Stanley has convincingly argued that neotenously generated new organisms tend to be small and unspecialised. Small animals have many more life niches open to them and can generate larger varieties to fill specific niches. Small unspecialised animals are able to generate many specialised varieties. Stanley further suggests that most speciation events occur in smaller varieties for a wide range of reasons. One very important one is that large animals have a greater tendency to go extinct and small animals have been able best to survive catastrophic extinction events. The net effect of this survival bias in favour of smallness being to increase the rate of divergence and diversification within individual lineages.[707]

Despite the enormous variety of life forms which inhabit the Earth today if it was not for mass extinction events it is very possible that it would be much greater. Studies of early Cambrian/late pre-Cambrian fossils reveals a large number of animal formations, most of which became extinct quite rapidly, presumably in some catastrophic event. It has been suggested that, we should reform our ideas concerning increasing diversity and come to appreciate that wide initial *disparity* was decimated,

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[705] Barnes, R., and Hughes, R., *Introduction to Marine Ecology*, 2nd Ed., Oxford, Blackwell, 1993 pages 180-1.

[706] S. J. Gould in the second half of his massive tome *Ontogeny and Phylogeny* (Havard University Press, 1977), usefully surveys the literature on neoteny.

[707] Stanley, S. M. *An Explanation for Cope's Rule*. Evolution 27 (1973), pages 1-26.

and that the diversity which we observe on the Earth is based upon the few forms which survived:

> "The sweep of anatomical variety reached a maximum after the initial diversification of multicellular animals. The later history of life proceeded by elimination, not expansion. The current earth may hold more species than ever before, but most are iterations upon a few basic anatomical designs...Life's history [is a] marked decrease in disparity followed by an outstanding increase in diversity within the few surviving designs."[708]

This initial decimation of disparity although further constraining the evolution of life, served as a bedrock for future diversification. Following each of the major extinction events massive diversification and speciation events have occurred. Because diversification is a cause of complexification Gould's assertion of the fact of post-catastrophic diversity undermines his own argument that complexity is not driven or built into biological evolution.

The vacuum or space left after decimation events allow those life forms that survived to expand. Whether this is simply the passive result of having no where else to go (similar to passive models of evolutionary complexification or the outward expansion of the universe) or is in someway driven by life itself has already been discussed in a previous article. Although the causes of the Permian extinction are not well understood the "rediversification during the succeeding Mesozoic-Cenozoic period" seems to have at least in part due to plate tectonics. As the super-continent began to break up in the Mesozoic this stabilised climate patterns, increased coastline and promoted provicialization and isolation of fauna and flora.[709]. Had the landmass of Earth not broken up and drifted apart it is perhaps possible that rediversfication may have been very much slower or much reduced. But it is precisely these

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[708] S. J. Gould, *Wonderful Life: The Burgess Shale and the Nature of History*, London, Hutchinson Radius, 1989, page 47 and 49.

[709] Barnes, R., and Hughes, R., *Introduction to Marine Ecology*, 2nd Ed., Oxford, Blackwell, 1993 pages 279-81.

“contextual historical and interactional constraints”[710] that generate diversity even in the face of catastrophe. Diversity is a source of stability as well as of opportunity. Species capable of diversifying are more likely to survive hence evolution is skewered towards diversification.

Diversity and redundancy:

Diversification of both species and ecosystem has many advantages in terms of the long-term survival of life. If a species that is carrying out a vital function in an ecosystem should be wiped out, for what ever reason, then it is vital to have other organisms which can take over. The earth has been subject to a number of catastrophes and continual climatic changes which have on occasions decimated the variety of life on Earth. High bio-diversity was presumably an important reason why life recovered from these events. Ecologists argue that, in the face of the present rapid rate of human induced habitat destruction and species extinction humans should make much greater effort to preserve biodiversity. Evolution may be skewed towards the survival of species which are best able to diversify and speciate, such as small, generalist and neotenously generated species-groups that are able to exploit new niches as they become available.

Biodiversity can be expanded through morphological as well as species diversity. The same animal may occupy different niches or habitats during its life cycle, for example the tadpole and the frog or the caterpillar and the butterfly. Phenotypic plasticity can also generate high habitat diversity, e.g. coral reefs of the Caribbean, unlike Indo-Pacific ones, do not effect the changes in morphology necessitated by

[710] Cohen J., *How Does Complexity Develop?*, page 12

increasing depth through species replacements, but, primarily by altering their morphology in response to different light levels.[711]

Modern research concerning the distribution and composition of ecosystem patches is revealing that there is considerable landscape diversity. It is this very diversity of landscape that allows for the support of a greater diversity of species suited to similar but different conditions. Beyond this, research concerning ecotones, which are transition areas, such as mangroves, shorelines, floodplains, etc., shows that the interaction between neighbouring ecosystems creates additional landscape, species as well as systems diversity.[712] Additional diversity results from constant change and disturbance in nature, but, generally, high diversity bio-systems are associated with stability, maturity and the optimal use of energy and available nutrients.

There is also considerable variation in differing gene pools within populations of the same species. Indeed periodic mixing of diverse genes from different populations seems necessary to maintain the vigour of populations. Hence, the idea that it is necessary to maintain viable meta-populations by making sure that individuals of endangered animal species are able to travel from one reservation to another by the planting of vegetative links. Similarly, there is considerable concern of the decline in agrobiodiverstiy of basic food crops. Hence the idea that it is necessary to help traditional rural communities to cultivate traditional varieties in situ through supporting them and being sensitive to their needs.

Diversity and the Evolution of Life:

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[711] Barnes, R., and Hughes, R., *Introduction to Marine Ecology*, 2nd Ed., Oxford, Blackwell, pages 173-4.

[712] Naaiman, R, and Decamps H., *The Ecology and Management of Aquatic-Terrestrial Ecotones*, New Jersey, 1990.

Differentiation is fundamental to the development of life, first in the development of different kinds of individual cells, then between multicellular organisms sometimes composed of up to 500 different types of cell, and lastly, the great variation and specialisation that exists between and within ecosystems. The origin, cause or processes that underlies differentiation, has been the subject of a great deal of speculation and there are no doubt many factors that account for it.

Because life's evolution was a highly non-random event, it is suggested that, the chemical and physical constraints which evolved in the "self-ordering of amino acids, may be characterised as a biomacromolecular big bang." "Amino acids sequence themselves in highly precise and reproducible non-random order. "Non random molecular beginnings", set the "initial limiting boundaries... yielding constrained evolution." [713] These thermodynamic and bio-chemical constraints do not deterministically straightjacket life. Rather, in order to generate randomness, variety and differentiation there must first be a non-random basis or platform from which it can emerge. "Randomization within" and through the "interplay" of "structural constraints is the basis for variation."[714] Variety and randomness only make sense, or come in to actuality and definition, against a bedrock of order.

The dynamic non-symmetrical non-equilibrium patterns of matter and energy within living systems, also increases the number and variety of living states available to an organism as symmetry-breaking "increases the number of distinguishable microscopic states."[715]

Thermodynamics, Mutualism and Multicellular Evolution:

[713] Sidney Fox, *Evolution Outward and Forward*, pages 23-9.
[714] Wicken, *Evolution, Thermodynamics and Information,* pages 86 and 89.
[715] Matsuno K., *Open Systems and the Origin of Protoreproductive Units*, in Ho M. and Saunders P. (eds.), *Beyond Neo-Darwinism*, Academic Press, 1984, page 69.

Structural and thermodynamic constraints have also both constrained and encouraged multicellular evolution. There appears to be an upper-limit to the size of each individual cell in relation to maintaining metabolic efficiency and structural coherence. Thermodynamic constraints that compel organisms to maximise or optimise thermodynamic efficiency may lie at the basis of the increasing differentiation, specialisation and mutualism. In early ontogeny "intensive generalist cells give way to specialised communities of cells", but the "generalist strategy is a thermodynamically expensive one." As the organism grows "mutualistic complexifiying networks reduce metabolic rate and dissipation", because specialised cells "have to do less metabolic work than generalised cells". "High rates of dissipation indicate developmental 'room' within given economic boundaries." Thus with multicellular evolution come the efficiencies or "economies" of "mutualism" and "specialisation", that is: cooperative patterns of a variety or diversity of specialised simples.[716]

Diversification, Specialisation and Complexification in Successional Development of Ecosystems in Relation to Thermodynamic Efficiency:

The beginning of the study of the energetics of ecosystems and their development is historically most usually associated with Elton, who invented the idea of the food-chain and the notion of trophic levels. Hutchinson similarly explored the energetics of natural systems, but unlike Elton, did so also from the point of view of mathematics, biogeochemistry and the newly emerging science of cybernetics. Lotka's book, *Elements of Physical Biology* also represents a landmark in the history of the study of the energetics of natural systems. "Lotka attempted to define a new area of biological research: physical biology. Physical biology was to be the

[716]Wicken, *Evolution, Thermodynamics and Information*, pages 148-9.

application of physical principles to complex biological systems, particularly that all-encompassing system that we now refer to as the biosphere. From the perspective a physical chemist, all biological processes could be reduced to exchanges of matter and energy among the compartments of a system. As such, biological systems were governed by the laws of thermodynamics…Because biological systems were complex and open…biological systems never came to a true equilibrium state, defined in terms of maximum entropy, but rather attained a steady state, defined in terms of constant energy flow…Natural selection always maximized the flow of energy and matter through this system"[717]

A great deal of investigation since Lotka's time (historically particularly associated with the work of Howard Odum) has gone into examining whether there is an energetic basis to ecosystem succession and determining general principles or equations to characterise them. Specifically, ecosystem scientists have been concerned to examine the energy constraints or efficiencies imposed upon ecosystems and how these influence the development, composition and patterning of them; how material and energy flows are rendered optimally efficient by ecosystems through a process of increasing differentiation, variation and specialisation.

Although modern non-equilbrium ecologists like to stress the enormous difference between their approach and earlier ones, associated particularly with the Odum brothers, there is no doubt that succession is, as a rule, generally predictable and based upon a process of increasing biomass, respiration, diversity and specialistation and a corresponding decrease in net production.[718] The reasons for this are related to energy efficiencies. As with the generalised cells of early ontogeny, pioneer species are thermodynamically inefficient generalists, which are

[717] Hagen, Entangled Bank, page 125.
[718] Odum, E., *Ecology and Our Endangered Life-Support System*, pages 195-8.

rapidly replaced by a wide variety of specialists which utilise matter/energy niches as they become progressively available. "Ontogenesis and Succession recapitulate hard-won evolutionary strategies involving organisational complexes elaborated to maximise thermodynamic efficiency".[719] It is not energy-efficient for a herbivore to digest all of the cellulose in its gut, thus leaving energy pathways exploited by detrivores. Thus "dissipation decreases" with "the elaboration of mutualistic networks that increases bio-mass whilst "reducing specific dissipation"[720], This eventually leads to a state in which energy is retained in the system for an increasing, and then optimal period of time. The differentiation of individual "auto-catalytic organisms" resulted in the ecosystem which is itself a closed autocatalytic self organisation or network[721], that:

"evolved by inventing new ways to capture resources, utilise them, and cycle elements back to the capturers. This strategy entails the co-operation of a community structure that positively feeds back on its abiotic matrix to draw resources into itself. The ecosystem too is a natural organisation, sustaining itself through dissipation."[722]

"The eminent Spainsh ecologist Ramon Margalef (1968) was among the first to demonstrate that ecosystem development involves a fundamental shift in energy allocation between production and respiration…Such a shift is definitely an ecosystem-level strategy"[723]

Variety and Differentiation when combined with specialisation, symbiosis, mutualism, community, predation, parasitism and etc., results in complex self ordering systems. The ability of various and differentiated specialists to co-operate or

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[719] Wicken, *Evolution, Thermodynamics and Information,* pages 150.
[720] Ibid, page 143.
[721] Ibid, pages 123 and 154.
[722] Ibid, pages 123.
[723] Odum, E., *Ecology and Our Endangered Life-Support System*, page 190.

integrate to create complex systems has "thermodynamic pay-offs"[724]. Social complexity resulting from differentiation, variety and co-operation in part came about because such strategies maximally or optimally utilise the energy-matter flows available to both the individual and the system as a whole.

Alternative thermodynamic Models and Diversification:

Beyond the standard thermodynamic models which I have just outline above there are other models emerging in the complexity community, such as those of Stewart, Ho, Cohen who believe that diversification is built into the universe, indeed any universe. They suggest, correctly in my opinion that there is a direct causal link between the diversity of elements and the level of complexity that is likely to evolve. Stewart's new physics and Kauffman's mathematical analysis of the adjacent possible and the tendency for symmetry breaking in dynamical systems leads Cohen to conclude that there is a tendency to diversity or evolution is skewered towards complexification:

> "We have imaginations that can work out the geography of notional phase spaces of the possible around the actual. Kauffman argues this in the frame of "the adjacent possible", that enables any behaviour or process to generate a more complicated future. And recursive complication will make it more interesting still"[725]
>
> "We must substitute a progressive cosmology for the classical physicist's entropic "heat-Death" view. We must understand how such progress loses simple constraints on genuinely emergent innovations. And we must show that there is an engine of diversification, as well as simply observing biology and technology enlarging their phase space of possibilities by accessing the adjacent possible. The new model, the universe "making it up as it goes along" applies easily to life and its complex, complicit evolution on this planet." [726]
>
> "Concepts like symmetry-breaking and bifurcation theory show that, as a general principle, the Universe must-and does "make it up as it goes along". And

[724] Wicken, *Evolution, Thermodynamics and Information,* pages 149.
[725] Cohen, J. *How Does Complexity Develop*, page 9
[726] Cohen, J. *How Does Complexity Develop*, page 2

> "along" therefore means onwards and upwards, evolving systems everywhere and everywhen."[727]

Environmental Divergence and Sympatric Speciation:

There are however an increasing number of biologists who believe, as Kropotkin did, that environmental divergence is a cause of sympatric speciation and serves as an engine of diversification and complexification in natural evolution. Bio-mathematicians when attempting to stimulate the evolution of bio-complexity and environmental divergence have concluded that speciation frequently occurs without prior allopatric isolation:

"speciation is effectively contingent on environmental divergence, and Stewart has proven mathematically that sympatric speciation is normal, ordinary, just what the universe would do once it has species"

In the computer experiment "all pods start out equal and each individual (as a member of its pod) "sees" all the other pods, there is initially a high degree of symmetry. But as the population density, or some other parameter, increases there is a sudden bifurcation, and two or three groups of pods diverge. Details of the divergence differ from occasion to occasion, but the result is two species where one was before, usually exploit the new environment slightly more efficiently."[728]

Stewart admits that he "doesn't know they pods speciate, only how"[729] Cohen in an attempt to explain Stewart's mathematical proof of a sympatric drive towards diversification invokes Kauffman's idea of the adjacent possible:

"Kaufmann in his later books builds a world-view on the discovery that systems bumble into the adjacent possibilities as often as they can, complicating

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[727] Cohen, J. *How Does Complexity Develop*, page 5
[728] Cohen, J., *How Does Complexity Develop*, pages 11-12
[729] Cohen, J., *How Does Complexity Develop*, page 12

themselves and anything in their context or environment."[730] Diversity causes complexification. Huge Increases in complexification (for example humans from chimps) occur randomly as a by-product from time to time due to the tendency for nature to create many different models of around the same basic themes. Eventually out of the many differing models something really novel and extraordinary is thrown up. At the level of the ecosystem, diversity and complexity are self-generating. When two similar birds opt to specialise exclusively on two different insects, two niches are created when there was only one before. These in turn create new micro-niches as well as new relationships with insects (with new symbiotic potential). At the other end of the scale these new species of bird may attract new forms of predation. Diversity expands ecosystem complexity (in the sense of the number of relationships) exponentially. Thus diversity leads to both qualitative growth and quantitative growth. Better quality animals and plants are created from time to time as well as the quantity of niches and life-strategies, which in turn generates greater ecosystem complexity and quality.

Occasionally a small twig (such as humans) on huge bush may end up being highly successful, but, once we abandon the linear notion of progress involving the idea of competition and elimination we realise that success does not involve elimination. If success is measured in terms of number, bacteria, which lie at the basis of biospheric regulation and all ecosystems, are by far the most successful type of organism. Fish, in terms of the number of species are still the most successful vertebrates, rodents the most successful mammals and deer the most successful herbivores. By far the most numerous species of animal life on Earth are insects. Mass extinctions are often the result of catastrophic events. Species have survived for

[730] Cohen, J., *How Does Complexity Develop*, page 7

incidental reasons. Mammals did not out compete and displace the dinosaurs. They were wiped out by a meteor impact and mammals simply filled up the vacant niches. Many species of dinosaurs in the form of reptiles and birds are still with us. Diversity increases because there are many ways to live on Earth, and species have not competed with one another to the extent that they eliminate different, or less-complex life forms. Either because they cannot (and humans haven't eliminated pathogenic bacteria or insect pests) or because they are not in competition with them (we are not in competition with dung beetles) or they are useful to us directly or to the ecosystems upon which we depend (as are our gut bacteria and dung beetles).

Chapter 7
Progressivism

History of the Idea of Progress

The idea that history had any direction or progressed is a very modern concept; a discovery of the Enlightenment. The Greeks, as well as most other cultures, thought in terms of eternal cycles or revolutions. In Medieval Europe, history viewed as Adam's fall and conceived retrogression from an initially perfect state. [731] Lyell, an early evolutionist (who influenced Darwin) viewed geological change as repetitive cycles. Lyell's uniformitarianism was an "idiosyncratic rejection of progress and belief in a cyclic, non-directional character of history."[732] The extraordinarilly (because it's rubbish) widespread and popular appeal of cyclic conceptions of history, such as astrology and similar belief systems, in some of the most technically and industrially 'advanced' parts of America, Europe and Asia, reveals that, perhaps the majority of people alive today continue to think of history in terms of repetitive cycles.

The ideology of progress, in the last few decades of the 19th century until the World War I, was the dominant ideology among industrialised nations. During the 1960's, among those same nations, there was a brief wave of optimism. Progressive sociology (not technological progress) has had a chequered history since WWI: the horrors of the depression and the Second World War, the slaughter of half a million people in Indonesia in the 1960's, or the tribal-national wars in Rwanda and Yugoslavia in the 1990s, the disgusting Marxist-Maoist-Leninist experimental

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[731] Hull D., *Progress in Ideas of Progress*, in Niteki, (ed) *Evolutionary progress*, page 27.
[732] Gould in Niteki, (ed) *Evolutionary progress*, page 322.

totalitarian dystopias of the last century (Stalin's Russia or Pol Pot's Cambodia). Capitalist imperialism and Colonialism were also justified by biosocial progressivism. The linking of imperialism tainted progressivist conceptions with racist and environmentally destructive ideologies. The linking of progress and biological evolution in the late 19th century, remains popular among the general public, but not with palaeontologists. The late S.J.Gould undertook a crusade against social and biological versions of progressivism. It is useful to compare Gould's ideas with those of Kropotkin who lived in a uniquely optimistic period when ideologies of progress were at their zenith. General criticisms of the concept of progress are applicable to assessing Kropotkin's position and the anarchist tradition we inherited from him.

Definition of the idea of Progress

Palaeontolgists distinguish between direction and progress. Direction describes a "series of changes that can be arranged in a linear sequence". Progress is a value judgement about whether evolutionary trends result or tend towards improvement. Direction is a "descriptive" term, and progress an "evaluative" one. "Progress implies change" or direction "but not vice versa."[733] Progress need not be a matter of morals, "efficiency, abundance, complexity", etc., can also serve as a standard of improvement.[734]

There are also important differences regarding the degree, rate and scope of progress. The gradualist or meliorist notion of "uniform, universal, invariable, constant, continuous or perpetual" change or improvement is largely "invalid".

[733] Ayala F., *Can Progress be Defined as a Biological Concept*, in Niteki, (ed) *Evolutionary Progress*, page 76.

[734] Ibid, page 78.

Progress makes most sense understood as "net progress which allows for fluctuations of value."[735]

The "scope of progress" is also relevant. The evolution of the elephant's trunk may legitimately involve a valid value judgement about the improvement of this particular feature. It is not however a value judgement about the elephant as such, nor about progress in general. Elephants may not be, and probably are not, better than anteaters, which also have highly specialised noses. "General progress may be invalid, but not against claims of particular forms of progress."[736] An example of a progressive particular is the evolution of the human brain which is several times larger than a gorillas or chimpanzees. But, it is not clear that there has been any net progress in brain size among primates. There has been "some small brained species present at all times", such that, progress is "not universal even among progressive orders."[737] "Evolution doesn't have one direction but lots of them."[738] This at least in part results from the fact that adaptations are always to local environments. Local adaptations cannot be general. Gould fails to notice that, paradoxically, the human brain, is a *generalist* feature. One of immense power. The brains genesis was a chance neotenous speciation event. Small mutations in early embryogenesis effecting developmental timing and delayed maturation led to a substantial increase in the quality and size of the brain/mind. This was a macro-evolutionary event rather than an adaption. Although the continued growth of the human brain may have been adaptive, clearly it was a general adaption of use in any environment and not specific to the particular region where modern humans first evolved.

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735 Ibid, page 79.
736 Ayala F., in Niteki, (ed) *Evolutionary Progress* page 81.
737 Ibid, page 329.
738 Hull D., in Niteki, (ed) *Evolutionary Progress*, page 45.

Anarchism and Progressivism

Kropotkin exudes optimism and late 19^{th} century progressivism; heralding the possibility of eliminating drudgery, poverty and overwork. Technological progress would be accompanied by social progress following a social revolution. The brutality of capital and state would be replaced by a new society organised by the workers and consisting of federations of self-governing, environmentally integrated communes linked by complex non-territorial networks of mutual interest. The workers at the level of individual factories and workplaces will self-organise the delivery of essential goods and services. In each village, street, or city quarter, the citizens would tear down unnecessary fences, divide up the housing and the land thereby creating a new landscape of collectively maintained workshops, farms and gardens.

Kropotkin's technological progressivism and social optimism was extended to his descriptions of biological evolution. Kropotkin's compares his social revolution with torrential natural phenomena, including tropical storms and geological upheavals. Progressive evolutionary change in industry, science, nature and society occurred in brief and intensely creative revolutions.

Darwin is often contrasted with Spencer, who was very enthusiastic about progress but, many passages in Darwin's works are similar. Contemporary palaeontologists and evolutionary biologists are fiercely anti-progressivist. Those sympathetic to retaining progressive concepts, advocate doing so, in limited contexts. And this view has been championed by Gould. Few professional biologists believe that biological evolution in any *general* or overall sense is progressive, as Kropotkin and his late 19th century contemporaries believed. But, the elucidation of contemporary complexity and chaos sciences has seen the emergence of new progressivist perspectives among bio-mathematicians and physicists (Goodwin, Ho, Stewart, Cohen etc.) that is beginning to effect mainstream biological thinking.

Fossil evidence suggests that evolution has occurred in fits and starts. Long periods of stasis are interrupted by comparatively rapid change. This characterisation contrasts with Darwinian gradualism. The general acceptance of Gould's and Eldredges's thesis of 'punctuated equilibria' in the 1980's resulted in a new consensus about the rate and distribution of evolutionary change The theory of punctuated equilibria is not based upon ideology but a clearer understanding of the various causes of macro-evolution and their interaction.

Marco-evolution involves comparatively large and rapid change (note not progress) at all levels, from the genome (e.g. heterochrony, molecular drive, fluid genome etc) to ecological and geological factors (i.e., the replacement of one ecosystem by another as a result of abiotic environmental changes).

Kropotkin in his articles for the *Geographical Journal* and the *Encyclopaedia Britannica* paid particular attention to the formation or disappearance of mountains, deserts, glaciers and associated fauna and flora. This geographic/geological approach meant that, he had a firm grasp of the complexities and theoretical difficulties of such factors as isolation, migration, environmental change and speciation. Kropotkin's Siberian experiences led him to consider harsh environments and eco-system change as a major force in evolution. A perspective he shares with Gould and Eldredgge. But, unlike Eldredge and Gould whom envisage speciation as occurring according to traditional allopatric model of isolation[739], Kropotkin also assigned some role to sympatric speciation in evolution. Sympatric speciation is compatible with a much

[739] Eldredge, N. *Macroevolutionary Dynamics*, McGraw-Hill, 1989, page 66.

higher rate of diversification and complexification. It makes 'progress' very much more like that that which can be conceived under a purely allopatric model.

Kropotkin defended the theories of 'the *direct influence of environment*' and the '*inheritance of acquired characters*'; believing that, organisms generated rapid and heritable physiological, morphological and behavioural changes in times of environmental challenge. He didn't accept Darwin's gradualism. Although direct inheritance of environmentally induced changes was rejected upon theoretical grounds for much of the 20th century opinions have recently been modified in the light of new evidence. It would, however, be absurd to claim that the potentially much more progressive mechanisms of direct inheritance represent the primary path of evolutionary change as Kropotkin, at times, in his book *Evolution and Environment*, suggests. Eldredge concludes that, geological record simply doesn't allow for such conclusions. Outside of global catastrophic events, individuals and species, if unable to migrate to other similar environments more usually than not go extinct in the faces of changes in the physical environment. Generally, "community types" are "stable" over "large geological time-scales"; "recurring, moving and replacing" one another.[740] Changes in temperature, salinity, moisture, brought about by (in human time scales very slow) geological events has resulted in a fossil record where one biotic assemblage, community or greater-ecosystem is replaced by another "rather abruptly"[741]. New ecosystems develop from the surviving species as well as new arrivals migrating from elsewhere. Evolutionary change "comes in bunches in cross genealogical contexts"; in definite "pulses" or "events". These "ecosystem

[740] Ibid, page 189.
[741] Ibid, page 191.

turnovers" are a "response to physical events" involving the "elimination of habitat without reference to adaptations."[742]

Eldredge's model of speciation is a variant of the classic allopatric model. Geological or migratory events cause ancestral populations to become isolated or subject to differing environmental conditions which effect genomic stability, behaviour etc., This causes breakdowns in mating recognition patterns, chromosomal incompatibility etc., between different populations.

Local or mini-extinctions rarely wipe out an entire taxa or general[743], but, life has on a number of occasions been subject to planetary wide interruptions where the dominant or majority of species became extinct.

According to Gould evolutionary events

may be entirely contingent. Mass extinction events have profoundly altered the course of life on Earth; changing the predominant life forms and ecosystems they in habit. The Permo-Triassic (225 mill.) extinction eliminated 94% of marine Metazoa. Those that survived did so for incidental reasons. Mammals evolved at the same time as the dinosaurs and spent most of their evolution in tiny niches unfilled by their reptilian neighbours. Mammals and birds survived the meteor impact because they were small. If the meteor had hit Mars rather than Earth the dinosaurs might still predominate and mammals had gone extinct:

> "the traits that enhance survival during an extinction do so in ways that are incidental and unrelated to their cause of evolution in the first place. This contention is the centrepiece of the different-rules model. Animals evolve their sizes, shapes, and physiologies under natural selection in normal times, and for specifiable reasons (usually involving adaptive advantage). Along comes a mass extinction, with its "different rules" for survival...There can be no causal correlation in principle between the reasons for evolving a feature and its role in

[742] Eldredge, N. *Macroevolutionary Dynamics*, McGraw-Hill, 1989, pages 191-6.
[743] Ibid, page 197.

> survival under the new rules. A species, after all, cannot evolve structures with a view to their potential usefulness millions of years down the road. Mammals may have survived the Cretaceous event because they were small, not because they embodied any intrinsic anatomical virtues relative to dinosaurs...And mammals were surely not small because they had sensed some future advantage; they had probably remained small for a reason that would be judged negatively in normal times—because dinosaurs dominated environments for large terrestrial vertebrates..."[744]

Biological history is seen by Gould a story consisting of singular and unique episodes; "inordinately complex events that happen only once". This is the "time arrow of irreversibility". "Historical complexity" is not amenable to the "stereotypical scientific methods" of the "experimental-predicative" and "verification-repetition"[745].

Whatever the model of inheritance, whether a particular species survives is, according to Gould about pure luck.[746] Adaptation to local environments, may for incidental reasons ensure continued survival, whilst superbly adapted organisms faced by abiotic environmental changes, go extinct. In the *long-term*, economic or environmental changes, resulting from abiotic, geological processes as well as occasional catastrophic events, may be the primary determinants of extinction or further evolution of species. It is important to note that, according to Gould's theory community "replacement" is conceived in "non-competitive terms"[747]. Versions of this thesis ere held by Kropotkin and most of the Russian evolutionary tradition with which he is associated and used as an argument against Malthus' over-population-competition model. However, Kropotkin's revolutionary or saltationist theory of biological and social change differs from the theory of punctuated equilibria which

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[744] S. J. Gould, *Wonderful Life: The Burgess Shale and the Nature of History*, London, Hutchinson Radius, 1989, page 307.

[745] S. J. Gould, *Wonderful Life*, pages 277-8.

[746] Gould, S.J., *On Replacing the Idea of Progress with an Operational Notion of Directionality*, in Niteki, (ed) *Evolutionary progress*, Chicago, University of Chicago Press, 1988, page 325.

[747] Gould, Niteki, (ed) *Evolutionary progress*, page 325.

conceives evolutionary change outside of global catastrophes in terms of "intergrading steps"; of "macro-evolution" rather than "mega-evolution".[748]

Gould's contingency thesis has been legitimately challenged by appealing to well known examples of the phenomenon of convergent evolution, progression, complexity. Convergent complexity is different from emergent complexity because it is a routine and predictable progression or evolutionary much more probable. The two most important examples of convergence within the context of this discussion are embryological development and the many well known examples of convergent evolution (eg. comparing features of the extinct marsupial the Tasmanian Tiger which evolved in isolation with similar carnivores elsewhere in the world):

> "The problem of a conservative/entropic universe versus a progressive one is most acute in embryology…Clearly, there is not a law of Conservation of Complexity. But the progressive increase of ordered structure, so precisely repeating the development of previous generations, is a wonderful process whose provenance must fit into a rational world-view"[749]
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> "Epigenesis "is often referred to as an *increase in complexity*. But, we should always add an important qualification. We should say that epigenesis is a convergent increase of complexity, in the sense that its outcome is neither random nor unexpected. Convergence is radically different from the divergent increase that takes place in evolution…Embryos are not chaotic systems, and embryonic stages are not phase transitions." Convergent evolution is not "order out of chaos."[750]

Similarly, there are many examples of computer experiments involving the generation of ordered dynamical patterning from simple rules that appear entirely predictable i.e., convergent. This has led some people in the complexity community and popular science columnists to become attracted to the idea that there may be fundamental or simple laws of complexification. More plausibly it seems reasonable

[748] Eldredge, N. *Macroevolutionary Dynamics*, McGraw-Hill, 1989, pages 125-6 and 66.
[749] Cohen J., *How Does Complexity Develop?,* Unpublished paper delivered to NATO conference on Complexity, Hawai'I Oct 2002 page 7
[750] Barbieri M., *The Organic Codes*, pages 3-4

to suggest that there are convergent or predictable emergences as well as genuinely unique and transformational emergent events that occur through the unique interaction of a variety of processes that are subject to particular historical contexts and constraints. Novelty is possible only within a bedrock of predictabilty but is not reducible to it. Gould's contingency model is contradicted by convergence but convergence is not the same thing as predictability, uniformity etc. A wall can be constructed in many different ways using a wide variety of materials in different environments and serving different purpose. But, what in general makes a good or useful wall will ensure that all walls possess certain convergent or similar features:

> "Gould's model is necessarily stretched by evolutionary convergence. Why should dolphins resemble fish, or the marsupials have produced so many parallels…by a variety of alternative routes. Anything that has appeared several times in evolution is far more probable than you think. Similarly those who have gleaned from chaos theory only the lesson that unpredictability and anarchy reign, neglect its most basic messages: deterministic chaos has its own stable and repeatable patterns. Pattern-seekers and reductionists alike risk the same mistake whenever they try to force life's rich diversity into a single holistic pattern or a single universal reduction. Concentrate on how the micro-dynamics "causes" the macrostructure and you will be swamped by contingency; think only of the macro-structure and you will confine yourself in a strait-jacket of excessive convergence. Our universe trades these two forces against each other to combine change and diversity with stability and selectivity."[751]

Cultural or Social Evolution

In *Mutual Aid*, Kropotkin classified human cultures in terms of developmental stages, arranging them in a progressivist linear way. At this time anthropology utillised archaeological concepts that classified societies in terms of ahistorical chronologies according to the level of technology (e.g. Stone, iron, bronze ages). Nineteenth century theories of cultural evolution, remain more legitimate in

[751] Cohen J. and Stewart I., *Chaos, Contingency and Convergence*, Non-Linear Science Today, Vol1, #2, 1991, page 13

archaeology because it doesn’t focus upon the details of kinship, marriage patterns etc., which are not preserved and can usually only be guessed. Social anthropology in contrast is premised upon the idea that, cultural values and manifestations cannot be judged according to levels of technology. It is not obvious, when handed by skilled huntsman that, a boomerang is any less effective than a rifle. An aboriginal sand-painting artistically is, as equally valid as a Mondrian. Marxist and Capitalist anthropology utillise socio-economic criteria such as the division of labour and the control or storage of surplus production. But were the structures of large tribal federative nations any less complex, in any absolute sense, to a small and isolated family living in a trailer park eating a TV dinner? Kropotkin, in this respect, differed in his thinking from the statist and, often, imperialist thinkers of his era, in that, he regarded the centralised state as an impediment to the evolution of what he considered to be the anarchist-federalist or true path of social progress. Kropotkin thought that scientific, technological, literary, horticultural etc., advancement was a fact of life in the 19th century and that social progress was possible, but not within the structure of the liberal-capitalism or a socialist state dictatorship.

Although indigenous people often made a significant impact upon their environments, their practices did not result in the wholesale logging of continents, ozone holes or the enhanced green house effect. Bio-regionally integrated and sustainable communities were developed among aboriginal peoples. Even if we solve the environmental problems of industrial and technological society and develop environmentally sustainable and integrated lifestyles, this would simply be getting back to a situation existing before the development of civilization. Despite the recent embracing of multi-culturalism, languages and cultures are disappearing at an alarming rate. Cultural and environmental diversity is thus declining rather than expanding. Even obviously progressive technological clades, e.g. snail-mail, telegraph, telephone, satellites, Internet, doesn't necessarily give us a better educated or more caring society. Is the car better than the train given that trains are faster, far less polluting, kind to wildlife and do not take up anywhere close to the amount of land? The notion of social progress is always subject to particular values. Social or cultural change can be viewed as better or worse according to the belief structure of the observer. An Islamic revolutionist might regard an Islamic state as closer to perfection, whilst being considered extremely retrogressive by a liberal democract. Half of the world's population go hungry each night and millions of children die of preventable diseases every year. One does not need to be a pessimist, only a realist, to believe that the notion of social progress is an illusion. Cultural or social 'change', rather than evolution or progress, may be a better or more accurate way to describe human history.[752]

Biological Progress

Extinction or survival of species and ecosystems, may be largely due to non-adaptive abiotic processes such as climate change. Moreover, a new ecosystem is no more or less optimal that the one it replaces.[753]

Unambiguous and universally applicable standards of measuring progress have not been articulated. Bacteria are the most robust, most efficient, longest surviving, most numerous and occupy more niches (miles under the earth to the human gut) than any other organism.[754] Bacteria do many things better than us.

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[752] Gould, S. J., *Full House*, 1998, page 219.

[753] Gould, S. J., in Niteki, (ed) *Evolutionary Progress*, page 325.

[754] This point is made by Ayala and Gould in Niteki, (ed) *Evolutionary Progress*, pages 75 and 330.

Interpreting palaeontological data presents many difficulties. Even if direction (let alone progress) is a feature of evolution (generally or within a particular lineage) it is difficult to substantiate this as a definite fact. Variation within species tends to oscillate, often in no particular direction during long periods of stasis such that "no net directional change occurs." "Punctuated equilibria is not punctuated gradualism."[755]

There are also many features which might enable palaeontologists to measure progress and direction scientifically that are not preserved in the fossil record. The "immune system may have progressed but is not preserved in the fossil record." There is also often a "lack of preservation of whole biotas". This makes meaningful measurement of community diversity/complexity problematic. "Constancy in the fossil record is the exception" rather than the rule. Often, only linear changes in "body size" or the "duration of lineages" is the only data available.[756] Duration and body size aren't appropriate standards for measuring improvement. At best they will only yield directional data. Even when data exhibits apparent directionality, this tells you nothing about whether it is random or not. Increasing complexity might perhaps be a more universally acceptable measurement of progress, but it is notoriously difficult to measure. Increasing diversity (a cause of complexification) is another possible standard for measuring progress. However, it may be difficult to assess whether "there really are more species or a greater diversity", in virtue of the fact that "more recent rocks have more fossils". Also, the historical existence of unexploited habitats, such as the land and air might mean that a "prediction of increasing diversity" is "straightforward" and not an indication of any progress at

[755] Eldredge, N. *Macroevolutionary Dynamics*, McGraw-Hill, 1989, pages 67 and 75.
[756] Raup D., *Testing the Fossil Record for Evolutionary Progress*, in Niteki, (ed) *Evolutionary Progress*, pages 293-5.

all.[757] A series of experiments undertaken by Raup and Gould simulating six dimensional random walks on computers reveal that, apparently generated direction when there is actually "nothing of consequence driving the system." Random systems can generate apparent direction. "Simply finding times-arrow is not enough."[758] (Cf. Langton's Ant)

In contrast to the Gouldian a-progressive or non-progressive view outlined above there is a body of previously discussed recent work by bio mathematicians (e.g. Kaufman's/Goodwin's 'adjacent possible' and Stewart's non-entropic universe/sympatric pods) that support the alternative view that nature of the universe and biological evolution is inherently driven towards diversification and complexification.

The problem with the non-directional, non-progressivist thesis, outlined above, is that, life does seem to have gone through a series of revolutions that are "hierarchical" and "non-arbitrary"; where "each stage" has been a "precondition for the next."[759] Maynard Smith categorises and serializes these revolutions as "replicating molecules, prokaryotic cells, eukaryotic cells, multicellular organisms, social groups with cultural inheritance."[760] Maynard Smith, like Gould, does not believe there was anything inevitable or driving these mega-evolutionary developments but feels that for these revolutions or mega-evolutionary events, the word progress seems an appropriate word to describe them. Another author, considering the same idea concludes "there are multiple levels at which selection

[757] Ibid, pages 298-300.
[758] Ibid, pages 296-8.
[759] Ruse M., *Molecules to Men: Evolutionary Biology and Thoughts of Progress*, in Niteki, (ed) *Evolutionary Progress*, page 117.
[760] Maynard Smith J., *Evolutionary Progress and Levels of Selection*, in Niteki, (ed) *Evolutionary Progress*, page 222.

acts, and higher levels evolved later than lower ones, a recognition of a kind of progressive change (whether for better or worse!) seems inevitable."[761]

In my opinion the ability or tendency for simples, molecules, DNA, RNA, protein complexes, genomes organelles, cells, groups of cells, groups of individual animals etc., to create collective systems or engage in cooperative or social behaviour is the major source of progress in bio-physics, evolutionary biology and human society. It is *sociality* (in its commensal, collective, symbiotic and mutualist forms and at all levels from simples/molecules to the human mind) that has been responsible for 'driving' (or at least making it much more likely) evolution toward greater levels of complexity. Progress in the history of life, if it means anything at all, appears to occur as a series of mega-evolutionary *social* revolutions, as Kropotkin suggested. It has already been discussed that it is possible to see evolution as the perfection of codes and memories; that progress occurs with the development of routine, predictable and repeatable social convergences premised upon common language, codes, conventions and memories.

Mass extinction events have always triggered substantial advances in complexity and rapid diversification of surviving life forms. This undeniable fact shows us that the trend towards diversification and complexification is a pervasive historical trend. After mass extinction events, diversity is rapidly restored, and complexity rises to new and unpredictable heights. In stable times ecological niches are filled. Space created by extinction and invasion creates novel ecosystems and potential new niches. Without this vacuum life doesn't change much. The aftermath ('nuclear winter') of the Cretaceous meteor impact may have wiped out everything above the size and below the tenacity of cockroaches and diatoms. If the meteor had

[761] Wimsatt W. and Schank J., *Two Constraints on the Evolution of Complex Adatpations and theMeans for Their Avoidance*, in Niteki, (ed) *Evolutionary Progress*, page 232.

been larger perhaps it would have. Qualitative leaps in diversity and complexity have been generated by *every* extinction event. Significant interruptions or alterations of fluid systems provide conditions ideal for the emergence of complex novelty. A combination of creativity and catastrophism is central to Bakunin's and Kropotkin's depiction of social revolution.

Cultural and Biological Progress

Kropotkin, believed in *biological* and *social* progress and a strong relationship between them. Contemporary biologists oppose linking biological and social evolution. They argue that, the principles of biological evolution are not applicable to cultural change.

Gould argues that, in contrast to biological change human social change is very much faster. Gould estimated that, the Cambrian "explosion" lasted some five million years and that the average length of a speciation event may be some five to fifty thousand years. Human civilization, in contrast, was "constructed from an unaltered brain" in a few thousand years.[762] The phenomenal *speed* at which society developed compared to biological evolution, Gould opines, is the result of fundamentally different *mechanisms* and *topologies*. Humans can amalgamate different traditions or lineages, through copying and improving upon ideas from elsewhere. A useful idea can rapidly spread all around the globe. Animals because their "topologies" are different usually cannot. Secondly, the *mechanism* of inheritance or transmission in human cultures is direct, whereas animals, Gould argues don't pass on new behaviour to their offspring. Drawing upon the neo-Weismannist tradition, Gould concludes that, human culture is passed on directly to

[762] Gould, *Full House*, page 220.

offspring, whereas animals are unable to pass on any acquired characters. Although this position is in general correct it is presented in a dogmatic way. Symbiosis involving an amalgamation of lineages allowed for the development of the nucleated cell and the colonisation of the land by plants and animals. Lichens and Corals evolved by an amalgamation of lineages; creating vital new ecosystems. Animals are able to pass on new inventions to both their social group, other groups, and other animal species. Technical knowledge that used to be held by magpies for drinking milk from soft-topped bottles once delivered to Australia's doorsteps spread throughout the country in a matter of years. Queensland's fearsome Moon Rat has learnt to open tin-cans. Animals learn what predators to avoid from watching the reaction of different species of animals. Cross-species DNA transfer mediated by retro-viruses and other transposable elements are also examples of amalgamation. There may be many, (poorly understood), inheritance processes of direct transmission of genetic and epigenetic changes acquired in an individual's life. The biological, social and cultural topologies of evolutionary change aren't so radically different in animals and humans as Gould asserts.

Natural selection has acted strongly upon 'higher' animals in favour of behavioural flexibility. The direct social inheritance of adaptive behaviour bypasses slower genetic processes for meeting environmental challenges by assimilating novel inventions. Information concerning new predators or food sources, and the techniques for avoiding or exploiting them are directly passed to offspring or other members of the group by simple imitation at the speed of light. The topologies and mechanisms of biological and cultural change are different, but, in terms of degree and speed rather than type.

Progress, even if it hasn't in actual fact eventuated, is applicable to social change. The rate of change in human culture results from powerful capabilities to amalgamate and directly transmit traditions between generations and peoples. But, evolution by amalgamation is also characteristic of mega-evolutionary events. Most notably the series of symbiotic and mutualist mergers that created the nucleated cell, multi-cellular organisms and the development of animal behaviours, societies or cultures.

Culture in addition to being a social or collective achievement also involves shared understanding or semantic content. As we have already seen Barbieri's (his book is subtitled: "An Introduction to Semantic Biology") explicit thesis is the idea that the operational processes of genetic, other organic codes and epigenetic memories in addition to energy, information and replication also requires meaning and understanding. Barbieri speculates that evolution or progress occurs with the perfection of organic codes and cellular (and other) collective memory systems. The genetic code is not simply a metaphor but a reality. (Does this allow for the possibility that the genome of a mouse or of a human are different genetic cultures using a common alphabet? In any case there are contemporary thinkers that believe that cultural concepts can usefully explain or posit the existence of social and collective behaviour at the very lowest levels of organised living matter.)

Should culture only describe human societies? Ants "have the most elaborate societies…but their claim to culture is rudimentary" In contrast, humans are "only weakly social".[763] Although true, different species or groups of ants have a remarkable variety of social structures, lifestyles, food sources and farming methods. Birds and mammals have complex societies involving learning and the rudiments of

[763] Bonner, *The Evolution of Culture in Animals*, pages 82-3.

culture. Like human children, most species of birds and mammals have an "extended youthful period of openness"[764] This can vary enormously between groups of the same species:

> "Oyster-catchers, depending upon whether their colony has a tradition of having a mixed diet or feeding only upon crabs and mussels may stay with their parents for many months longer due to the difficulty of perfecting the method of opening them up—although both feeding behaviours are inherited to some extent—tradition calls forth one to the exclusion of the other."[765]

"Cultural innovation", such as the crèches administered by a few male emperor penguins, (thereby allowing the remainder to go of and hunt), has enabled them to colonise a harsh environment.[766] In mammals the "young may be reprimanded for doing a poor imitation", by means of a "nudge poke or slap to encourage better performance". Information is "reinforced" through "positive and negative parental guidance".[767] It may be more appropriate to regard "human culture" as an "emergent" phenomenon with a "biological basis".[768] Among animals, society and culture are two ends of a continuum, not a dichotomy.

Kropotkin's typically late 19th century linking of cultural and biological evolution cannot so easily be dismissed. But, such links are not very strong or indeed very relevant. Human culture is unique; a quantum development of enormous scope that, for most practical purposes can be easily differentiated from the social behaviour of our closest primate relatives. Homo Sapiens unique developmental pattern enabled the evolution of cultural complexity:

> "In many ways we appear to have evaded the specializations of other species by remaining, in effect, ape babies all our lives…At some time some descendants of the ancestors we share with chimpanzees failed to grow up and so preserved the wider potentialities of infancy that permitted the initiation of the human condition…Gould emphasizes that developmental retardation is already

[764] Ibid, page 122.
[765] Ibid, page 174.
[766] Bonner, *The Evolution of Culture in Animals*, page 156.
[767] Ibid, page 126.
[768] Ibid, page 186.

> characteristic of primates; we have taken that change a step further…The apes show a steady development from birth to maturity, while the human baby changes with an amazing speed—in fact, a rate of growth comparable to that of the embryo—for up to a year, then slows to a rate similar to that of 'normal' postembryonic development. If we look at ourselves as mammals among other mammals, therefore, we see that we should be born twelve months later than we are…Nowhere else in living nature, so far as we know, does just this pattern of premature sociality occur…Portmann calls this unique period of postembryonic, yet still embryonic, growth, the period of *social gestation*…The human being demands not only nine months in the physical uterus of the mother but a further twelve months in the social uterus…In short, the whole biological development of a typical mammal has been rewritten in our case in a new key. The whole structure of the embryo, the whole rhythm of growth, appears to be directed to the emergence of a culture-dwelling animal…The postponement of sexual maturity to a date relatively later than is characteristic of other species permits a long period of apprenticeship and the gradual assumption of responsible personhood. And at the other end of the time span, the prolonged and gentle slope of human senescence provides opportunities for rising generations to profit from the richer experience of the old and wise. Thus at every level and at every stage of our existence we live out the uniquely flexible, uniquely creative pattern of configured time (as Portmann puts it) that is a human being"[769]

The development of human language and conceptual analysis has also led to an ideology of progress and the setting of goals and purposes. The concept of direction or progress has itself been a cause of cultural change, in which "purposes are made and not found"[770] Direction or progress in biological evolution seems to require some goal or goals to which it is headed. Nature is completely blind to such considerations. In the human realm goals can be discovered (whether moral, social or economic), and new ones, imagined, aimed at and achieved, without descending into teleological absurdity. There is no purpose or direction in nature and our conceptions of social and industrial progress are entirely of our own making. In many ways it makes little sense to apply these human concepts to nature. But, life has undeniably

[769] Eldredge and Greene, *Interactions*, pages 179-83.

[770] Provine W., *Progress in Evolution and Meaning in Life*, in Niteki, (ed) *Evolutionary Progress*, page 52.

evolved by a series of progressive revolutions. Direction or progress in nature was not pre-programmed, nor inevitable, but it has progressed. The notion of social progress or cultural evolution is far more problematic. Civilisation has not solved the problems of hunger or made us happier. Industrial-scientific culture has yielded profound environmental and social challenges, that haven't been solved. It is difficult to unambiguously claim that we have progressed much beyond so-called 'primitive' cultures that were destroyed capitalist imperialism.

Belief in the ability of grassroots, non-governmental social revolutions is not entirely dead, even if it is at a very low ebb. The Zapatistas, in Mexico incorporated many of the ideas of anarchism into their self organisation of several million peoples. (Zapata's ideas came from the writings of the prominent anarchist Ricardo Flores Magon[771]) However, the idea that our present social and environmental problems can be overcome by a sweeping proletarian revolution, as Kropotkin suggests, in the light of the history of the 20th century, seems to most people, essentially foolhardy and, at best, a very remote possibility.

However, Kropotkin's vision of self-sufficient ecologically integrated cities and villages is regarded by leading ecologists, e.g. Odum, as a desirable goal because, it would enable the human species to learn to live in harmony with living processes. Reckless overexploitation of both cities and the natural environment are leading more and more people to realise the need to reform our life-ways.

Odum, who like Kropotkin is an optimist, in his recent books compares human society to youthfulness in ontogeny and ecosystem succession. Humans have yet to outgrow their pioneering, growth orientated period and develop more mature, stable, ecologically integrated and energy efficient societies focused upon qualitative

[771] For an overview of their social organisation see Flood A. *The Zapatistas and 'Direct Democracy'*, Anarcho-Syncicalist Review #27 1999, Illinois pages 16-7.

improvement rather than quantitative growth; where people acting locally and globally will concentrate upon enriching and diversifying their relationships with nature and with one another. Odum, who is perhaps the most famous ecologist of the 20th century, advocates an ecological vision of society that is basically the same as Kropotkin's. But, like most contemporary environmentalists Odum thinks that, the ecological transition from adolescence will come about through growing social maturity and ecological sensitivity. This is to be supplemented by the "more aggressive use of legal and political authority"[772] in the enforcement of green legislation within the context of a responsive social democratic state. Although some environmentalists are willing to engage in acts of civil disobedience, only a small minority conceive of realising an ecological society by revolution. Liberal greens believe in peaceful means with the support of a well thought-out environmental legal structure enforced by a political system not dissimilar to that which we have today.

It is impossible and most probably foolhardy to predict the future. Climate change either from global warming, the onset of another ice age or perhaps environmental breakdown of basic food sources due to soil degradation, over-fishing etc., may in the future reveal the bankruptcy and stupidity of state-capitalist over-exploitation of nature, necessitating radical political solutions. Though history tells us that in times of widespread hardship and economic hopelessness the masses are more often drawn to the political right. On the other hand, rapid advances in technology and science when applied according to ecological criteria may deliver us a more integrated and just society by peaceful or evolutionary means. In any case, although there are few people who believe that an ecological society can be created

[772] Odum, *Ecological Vignettes*, page 130.

by revolutionary means, most people in the present age would regard the development of the sort of society outlined by Kropotkin and Odum as *desirable*, but perhaps utopian. Again others, believe in the *necessity* of developing moderately sized, socially cohesive and self-sufficient urban ecosystems but have difficulty in picturing how we might get from here to there. Social Revolution is one answer, but there are others. It is worth remembering, however, that two of the most important founders of modern ecological thinking, Reclus and Kropotkin, were both anarchist revolutionaries, who believed in torrential visions of social change by means of the self-organisation of the masses. Just as volcanoes and glaciers have the function of bringing fresh nutrients to the Earth, revolutions, Kropotkin thought, though hugely destructive and sometimes terrible, were necessary for society, like nature, to bring in renewed vitality or adapt to the changing conditions of life on Earth.

Chapter 8

‘Scientific’ Metaphors: Struggle and Cooperation

Kropotkin interpreted the Darwinian metaphor of struggle just the way that Darwin himself had intended. Kropotkin relates, how he had to remind Romanes, when he was chairing a lecture he was giving on mutual aid, of what Darwin had actually said in respect to his own understanding of his struggle metaphor:

“Romanes at the end of my lecture pointed out the significance of my work and summarised it in the following words: “Kropotkin has unquestionably proved that although external wars are waged throughout the whole of nature by all species, internal wars are very limited, and in most species there is the predominance of mutual aid and co-operation in various forms. The struggle for existence, says Kropotkin, is to be understood in the metaphorical sense” I was seated behind Romanes and I whispered to him: “It was not I, but Darwin who said so, in the very beginning of the third chapter, ‘On the Struggle for Existence.’” Romanes immediately repeated this remark to the audience and added that this just the right way to interpret Darwin’s term,--not in a literal but in a figurative sense.”[773]

Biological and Social Sciences

Biology includes all the life sciences. The biological spectrum ranges from virology, genetics, bacteriology, entomology etc., to zoology and ethology. Does ethology provide a bridge from the biological sciences to the human social sciences? Theses natural empistemological breaks, bacteriology, cell biology, entomology

[773] Kropotkin, *Ethics*, page 287, footnote 29

etc., correspond with breaks and leaps in the evolution of life. The evolution of genomes, of bacteria, of nucleated cells, then plants, insects, birds, mammals etc.

Once we leave the microscopic world and explore social-entomology, social-ornithology, the societies and behaviour of mammals etc., we progressively move from biology to the study of animal behaviour (ethology) and Zoology.

Many biologists and social scientists reject the idea that any strong conclusions can be drawn between complex human societies and animal groups.

In the narrow sense of biology, *Mutual Aid* is a zoological, historical and anthropological work and not a biological work. Kropotkin, in *Mutual Aid* has little problem in moving from the societies of birds, ants, parrots, monkeys to the social dynamics of stone-age society (though the linear and, hence, derogatory concept that the stone-age society was less complex than the barbarians, from a modern perspective leaves a lot to be desired).

Kropotkins treatment of the relationship between biology and social behaviour irritates biologists because contemporary socio-biology and its descendant, evolutionary psychology, like 19th century social Darwinism, from which it evolved, in virtue of its very definition causally and unproblematically links socio and bio. This has particularly angered many biologists and social scientists. Gould, as noted in a recent popular science book has waged “a twenty-year campaign of savage polemic against evolutionary theories of human behaviour.”[774]

[774] Sterelny, K, *Dawkins vs. Gould: Survival of the Fittest*, UK, Icon Books, 2001, page 129

Although “Gould *hates* sociobiology”[775], he hates it because, he believes that it is inappropriate to justify economic and political statements through appeal to animal behaviour and evolutionary biology. In his discussion of Kropotkin’s *Mutual Aid*, Gould criticises him for the same reason:

> “I like to apply a some what cynical rule of thumb in judging arguments about nature that also have overt social implication: When such claims imbue nature with just those properties that make us feel good or fuel our prejudices, be doubly suspicious. I am especially wary of arguments that find kindness, mutuality, synergism, harmony—the very elements that we strive mightily, and so often unsuccessfully, to put into our own lives—intrinsically in nature.”[776]

Gould objects to the metaphors of competition, struggle and co-operation regarding them all as anthropomorphic and unscientific. However, although Kropotkin did try to draw morals lesson from the social animals as Gould claims, Kropotkin’s analysis of the structure of human populations as socially adaptive is much more complex and sophisticated than that accredited to him by Gould. As I will show, his overall thesis is essentially similar to that of Wynne Edwards. Kropotkin also developed Darwin’s ideas on the relationship between man’s moral conscience and the evolution of animal groups in several interesting directions

Group Selection, Structured Populations and Environmental Conservation Among Hunter-Gathers:

In the third chapter of *Mutual Aid* and in his *Ethics* Kropotkin, attempts to, form a bridge between the findings of zoology anthropological studies of hunter-gatherer societies and the social structures of animals.

[775] Sterelny, K, *Dawkins vs. Gould*, page 129
[776] Gould, S. J., *Bully for Brontosaurus*, Hutchinson Radius, 1991, page 338

Kropotkin, begins by noting the huge concentrations of debris; discarded shell heaps and flint-stones that must have taken generations to accumulate. Humans lived a social life. They did not wander around in loose aggregations. Nor, on the other hand, did they live as isolated nuclear families:

> "Far from being a primitive form of organisation, the family is a very late product of human evolution...Societies, bands, or tribes—not families—were thus the primitive form of organisation of mankind and its earliest ancestors. That is what ethnology has come to after its painstaking researches. And in so doing it simply came to what might have been foreseen by the zoologist. None of the higher mammals, save a few carnivores...live in small families, isolatedly straggling in the woods. All others live in societies. And Darwin so well understood that isolately-living apes never could have developed into man-like beings, that he was inclined to consider man as descended from some comparatively weak *but social species*, like the chimpanzee...Zoology and paleo-ethnology are thus agreed in considering that the band, not the family, was the earliest form of social life"[777]

A tribe usually consists of a number of loosely federated bands over a wide geographic area or natural region. However, although there existed this federation or community of communities, the band is often autonomous to a very large degree. Kropotkin suggests that this structure is similar to regional or meta-populations of birds and mammals. Evolution had favoured the group, rather than the individual or the species, and this tendency was observable among animals and those surviving hunter-gatherer societies:

> "Within the tribe the rule of "each for all" is supreme, so long as the separate family has not yet broke up the tribal unity. But that rule is not extended to the neighbouring clans, or tribes, even when they are federated for mutual protection. Each tribe, or clan, is a separate unity. Just as among mammals and

[777] *Mutual Aid*, page 65.

> birds, the territory is roughly allotted among separate tribes, and, except in times of war, the boundaries are respected"[778]

Kropotkin's and Wynne-Edwards description of the social structuring of hunter-gatherers, matches what we know of the bushmen of southern Africa and the Australian Aborigines, as well as the communal-village system of agricultural peoples in Africa, prior to colonisation. There exists considerable evidence within conservation biology and other literature generated by efforts to maintain wild life populations confirming that social mammals and birds live in stable groups within a stable regional or meta-populations.[779] Kropotkin also discusses taboos upon inter-marriage between band members that evolved to prevent inbreeding (extreme philopatry).[780]

Kropotkin also devotes many pages to discussing the apparent contradictions between the morality, judiciousness, honesty, warmth and straightforwardness of hunter-gatherer people with the widespread practice of cannibalism and infanticide.

Infanticide he attributes to the necessity of controlling population by matching the number of small babies with the resources available to them:

> "...When we see that these same loving parents practice infanticide, we are bound to recognise that the habit (whatever its ulterior transformations may be) took its origin under the sheer pressure of necessity, as an obligation towards the tribe, and a means of rearing the already growing children. The savages, as a rule, do not "multiply without stint", as some English writers put it. On the contrary, they take all kinds of measures for diminishing the birth-rate. A whole

[778] *Mutual Aid*, pages 88-9.

[779] Although there is a wealth of literature the following book contains some useful articles. *Cascadia Wild: Protecting an International Ecosystem*. Edited by Mitch Friedman and Paul Lindholdt, Greater Ecosystem Alliance and Frontier Publishing, Oregon 1993.

[780] Ibid, pages 70-1.

series of restrictions, which Europeans certainly would find extravagant, are imposed to that effect, and they are strictly obeyed. But notwithstanding that, primitive folk cannot rear all their children. However, it has been remarked that as soon as they succeed in increasing their regular means of subsistence, they at once begin to abandon the practice of infanticide."[781]

As has already been discussed, Wynne Edwards has, on the basis of substatial evidence argued that infanticide by means of either cannibalism, neglect or abandonment, is a common method of conserving resources through population control from corn weevils to birds to hunter-gather societies. Cannibalism in animals is often engaged in as a last resort, as chemical (pheromones) signals and physiological (caused by poor nutrition) reactions, also play their part. Similar, apparently cruel measures for dealing with the old or the infirm (parricide) were also developed in many societies in the past as a method of conserving scarce resources in times of hardship. Kropotkin argues that such practices must be seen as developing as an adaptive response to regulate population and food supply and must not be judged according to the standards of present day European society, which, he adds, is not without its own horrors and hypocrisies:

> "But if our scientist had lived amidst a half-starving tribe which does not possess among them all one man's food for so much as a few days to come, he probably might have understood their motive. So also the savage, if he had stayed among us, and received our education, may be, would understand our European indifference towards our neighbours, and our Royal Commissions for prevention of "baby farming"".[782]

Although infanticide is hard to understand it is important to appreciate that in times of famine a mother may not produce enough milk to sustain the child.

[781] *Mutual Aid*, page 81.
[782] *Mutual Aid*, page 83

Obviously abortion, in the absence of modern surgical techniques, is dangerous, and would often result in the death of the mother, who may already have dependant babies and children. Nomadic hunter-gatherers were also unable to travel with too many very young babies, especially in harsh, changeable environments. Repugnant practices were a brutal, *but*, *necessary,* means of ensuring the survival of the band and their environmental resources.

Kropotkin further suggests, that the more repugnant and perverted manifestations of cannibalism, parricide and infanticide were due to the ill-effects of religion. The warrior believing that he gained strength and mystical power through eating his enemy. In this way cannibalism was institutionalised.[783] It lost its connection with the need to conserve resources and became a cultural and religious habit. This can be illustrated by the fact that although infanticide was a necessity in the central arid regions of Australia (because of limited water), it was practised in coastal regions (with adequate water) for religious and cultural reasons, rather than economic and environmental concerns. Eyre, for example, "amongst the tribes around Adelaide" was of the opinion that cannibalism was practised "to enable them to become sorcerers, they have at one period to eat the flesh of young children, and at another that of an old man". But it did not appear that "they partake of each kind more than once in their life time."[784]

[783] *Mutual Aid*, page 84.
[784] *The Native Tribes of South Australia,* Adelaide, Wigg and Son, 1879, page XV.

It is of some interest that Wynne-Edwards, drawing upon the work of Birdsell[785], comes to identical conclusions to Kropotkin, upon the stable and universal nature of the band structure of hunter-gatherer societies as well as the role of infanticide in hunter-gather societies in controlling population.[786]

Morality and Nature

Darwin attempted to explain our "moral sense of conscience…exclusively from the side of natural history"[787] Darwin recognised that the group was of primary importance in explaining the development of sympathy and social conscience among the higher animals. Following Darwin, both Kropotkin and Wynne-Edwards argue that, our senses of guilt, social consciousness, sympathy and remorse etc., could only have evolved within a group lifestyle. Clearly the intensity of, for example, socially induced shame could not have evolved if we had lived in loose anonymous herds or aggregations, and even less so, if we had in our development lived as isolated individuals. These feeling also could not be solely attributable as having originated as an extension of parental devotion. The fact of social conscience is therefore an indirect proof of the importance of the group, band and smallish tribe within the development of our species and of the animals from which we evolved. These feeling along with the sense of solidarity engendered by

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[785] Birdsell, J. B., *Spacing Mechanism and Adaptive Behaviour of Australian Aborigines*. in F.J. Ebling and D.M. Stoddart (eds.) *Population Control by Social Behavior*, London, Institute of Biology, 1978, pages 213-44.

[786] *Evolution through Group Selection*, pages 35-6 and 223-4.

[787] Darwin, C., *The Descent of Man* (1871) Chap III. Princeton Uni Press edition, 1981, pages 70-1.

the intensity of social living were the origin of our moral concepts and have served to counteract our more egotistical desires:

> "If the savage has infringed one of the smaller tribal rules, he is prosecuted by the mockeries of the women. If the infringement is grave, he is tortured day and night by the fear of having called a calamity upon his tribe. If he has wounded by accident any one of his own clan, and thus has committed the greatest of all crimes, he grows quite miserable; he runs away in the woods, and is ready to commit suicide, unless the tribe absolves him by inflicting upon him a physical pain and sheds some of his own blood."[788]
>
> "the fact is that self-sacrifice in the interest of an ants' nest, or for the safety of a group of birds, a herd of antelopes, or a band of monkeys, *is a zoological fact of everyday occurrence in Nature*—a fact for which hundreds upon hundreds of animal species require nothing else but naturally evolved sympathy with their fellow-creatures"[789]

There is no logical necessity for our sense of loyalty, honour and obligation. But regardless of the particular moral codes of any given society these feeling and sentiments were central to the social structure and survival of the group. Even criminals have their own sense of honour and obligation to one another.

Darwin made a special note of the "moral sense in dogs and elephants" and concluded that, the higher development of morality in humans resulted from habit and our greater intellectual and linguistic capabilities.

Wynne-Edwards also suggests that the evolution of our moral sense is a result of group adaptation, as is, the significant lessening of moral concern for strangers or non-group members.[790] This lack of concern for outsiders or foreigners,

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[788] *Mutual Aid*, page 88.
[789] *Ethics*, page 43.
[790] *Evolution through Group Selection*, pages 356 and 361.

Kropotkin, believed, provided further evidence for the predominance of the group or neighbourhood in our evolution:

> "Unfortunately, in the tribal system, the rule "everyone for all' does not extend further than the individual's own tribe...[and] generally speaking, inter-tribal relations are entirely different from relations within the tribe. And in the subsequent development of the human race no religion could eradicate the conception of a "stranger". Actually, religions most frequently become a source of ferocious enmity, which grew still more acute with the development of the State. And as a result a double standard of ethics was being developed, which still exists in our own time and leads to such horrors as the recent war."[791] [World War I]

If one does not wish to ascribe a super-natural origin to morality then it becomes necessary to look at how morality may have developed out of nature. This tradition, as with the metaphysical and politco-legal conceptions, has had a long history. It can be clearly discerned among the 18th century thinkers, such as Adam Smith and David Hume, whom Kropotkin discusses at length in his Ethics and whom sought to show how natural feelings of sympathy for ones relatives and neighbours, when combined with habit, utility, reason and intelligence, were the source of our ethical conceptions. Kropotkin suggests that, like biology, which had shown over the ages how "unicellular organisms evolved into... the higher mammals and Man, Ethics must demonstrate how moral conceptions were able to develop from the sociality inherent in higher animals and primitive savages, to highly idealistic moral teachings."[792]

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[791] *Ethics*, pages 78-9.
[792] Ibid, page 67.

Kropotkin was never able to complete *Ethics*. Although the first volume on the history of Ethics was substantially completed, the second volume, which was to have presented his own ethical theories was barely started before his death. Kropotkin in the first few chapters of the Ethics, did however, in my opinion, make a substantial contribution to our understanding of how conceptions of morality developed among hunter-gatherer peoples. His thesis is a simple one, but one that is compelling, as well as being beautifully and convincingly presented. It is, moreover, a significant advance upon the suggestive comments made by either Darwin or Wynne-Edwards.

Kropotkin asserts that the explanation of how ethical conceptions grew out of the sociality of animals and early humans must be "analysed from the two-fold point of view: of the *inherited ethical tendencies*, and the *ethical lessons* which our primitive ancestors gained from the observation of nature."[793] Kropotkin not only thought that certain ethical predispositions had originated in animal and human societies and become biologically innate, but, also that, humans had further developed their conceptions of morality through observing the social life of the animals that surrounded them:

> "Our primitive ancestors lived with the animals, in the midst of them. And as soon as they begun to bring some order into their observations of nature, and to transmit them to posterity, the animals and their life supplied them with the chief material for their unwritten encyclopaedia of knowledge, as well as for their wisdom, which they expressed in proverbs and sayings. Animal psychology was the first psychology studied by man...and was the subject of the very first rudiments of art, inspiring the first engravers and sculptors, and entering into the

[793] Kropotkin, *Ethics*, page 49.

composition of the most ancient and epical legends and cosmogonic myths. The first thing our children learn in zoology is something about the beasts of prey—the lions and the tigers. But the first thing which primitive savages must have learned about nature was that it represents a vast agglomeration of animal clans and tribes: the ape tribe, so nearly related to man, the ever-prowling wolf tribe, the knowing, chattering bird tribe, the ever-busy ant tribe, and so on"[794]

Kropotkin goes on to suggest that the hunter-gatherer watched how animals posted sentries, how they protected their young when attacked, and the tactics they used when their herd or band was in retreat. He suggests that the great autumn gatherings of birds or mammals may have been the inspiration for the "great autumn gatherings of entire tribes."[795] Not only had our ancestors learnt the benefits of settled living or the use of cereals from the beavers and the winter stores of rodents, but in their "legends the wise man of the tribe learns wisdom from the beaver, or the squirrel, or some bird."[796] Our ancestors considered that the animals were as fully conscious as themselves and communicated to one another in their own societies. Hence a crocodile, wolf, bear or snake was never wantonly killed, as the crocodiles would take revenge. He relates how Africans would examine the corpse of a slaughtered crocodile, and if it were found that it was not the individual responsible for having eaten one of their people, they would "make all sorts of expiatory amends to the crocodile tribe."[797] This sense of justice and equity toward other animals, was Kropotkin thought a pervasive feature of natural order:

"When we see that scores of thousands of different aquatic bird come in big flocks from the far South for nesting on the ledges of the 'bird mountains' on the

[794] *Ethics*, page 51.
[795] Ibid, page 55.
[796] Ibid, page 57.
[797] Ibid, page 56.

> shores of the Arctic Ocean, and live here without fighting for the best positions; that several flocks of pelicans will live by the side of one another on the sea-shore, while each flock keeps to its assigned fishing ground; and that thousands of species of birds and mammals come in some way without fighting to a certain arrangement concerning their feeding areas, their nesting places, their night quarters, and their hunting grounds; or when we see that a young bird which has stolen some straw from another bird's nest is attacked by all the birds of the same colony, we catch on the spot the very origin and growth of the sense of equity and justice in animal societies...For them [hunter-gatherers], all the animals—beasts, birds, and fishes alike—were in continual communication, warning each other by means of hardly perceptible signs or sounds, informing one another about all sorts of events, and thus constituting one vast community, which had its own rules of propriety and good neighbourly relations. Even today traces of that conception of nature survive in the folklore of all nations."[798]

Kropotkin does not actually ask us to believe in these somewhat simplistic notions of animal ethics and justice, but suggests that this is how our ancestors perceived the natural world around them. Observations of social order and stability among animals profoundly influenced our earliest conceptions of morality. Moralistic animal stories still remain an important component of children's literature and provide a vital function in educating our youngsters about the benefits of virtue and of good deeds. At the time that Kropotkin was writing, these 'primitive savages' were considered, by most Europeans as without morality. Kropotkin had encountered many indigenous and tribal peoples in his Siberian explorations. He was sensitive to their world view and the abundant nature that still surrounded them. Unlike contemporary forms of neo-primitivism, which view stone-age peoples in a romantic light, Kropotkin never idealised them. He was however, one of the founders of a school of thought (which in more recent times continued through P.

[798] Ibid, pages 16 and 54.

Picasso, D.H. Lawrence and the anthropologists of the 1950's and 60's) that sought to rediscover the 'primitive' and derive inspiration and knowledge from it. These 'primitive' tribesmen, knew the animals they hunted intimately. They could track an animal for days over many, many miles. In order to escape death they had to understand the social strategies that the wolves or the lions used to capture their prey. Knowledge of animal societies, and the lessons which they learnt from them, was incorporated into their moral concepts. These lessons remain with us in the timeless animal stories that still passed on from one generation to the next.

In the final chapter *Ethics* Kropotkin briefly examines the works of J. M Guyau, whose work he regarded very highly. Guyau, Kropotkin observes, thought that ethics was in someway a counterpart of life's impulse to "growth and development." Humans' need to "live a full, intensive, productive life; to extend its limits, to accelerate its tempo, to fill it with varied impressions and emotional experiences." This "thirst for *struggle* and risk" leads people to "embark upon a distant voyage, undertake and educational enterprise" or advance a daring "new hypothesis". The "desire for risks and the *struggle*…to bring intensity into [one's] life", Guyau claims, according to Kropotkin, although separate from social instincts, also leads to "self-sacrifice" and "courage". Kropotkin observes that, just as "in *struggle* and in danger man hopes for victory…animals are fond of play connected with danger: thus, for example, certain species of monkeys like to play with crocodiles. And in men the desire to combat against all odds is very common."[799].

[799] Kropotkin, *Ethics*, Chapter 13, pages 322-332, *passim*.

Although this thesis seems intuitively correct, it is difficult to assess it's veracity. We do seek adventure, experiment, variety, intensity and struggle. Whether this is one source of human morality, including self-sacrifice, is a poetic rather than a scientifically verifiable proposition.

Kropotkin's use of the word 'struggle' in this sense highlights the limitations as well as the conceptual suggestiveness, multidimensionality or flexibility of Darwin's 'struggle' metaphor.

'Scientific' Metaphors:

The struggle metaphor can be adapted to all most any social viewpoint, ranging from the moral or political extremes of altruism and egotism or communalism and capitalism. Metaphors and analogies, although often simplistic, partisan or anthropomorphic as Gould asserts, may also be very fruitful; leading to greater scientific and human social understanding. This can be seen in the rich and diverse thinking, some of which we have been examining, that has been generated by discussion and consideration of Darwin's various metaphors.

Before considering Kropotkin's writings upon speciation it is useful to conclude this section by looking at the historical usage and epistemological or ontological status of the metaphors of competition, co-operation as well as a variety of others commonly used images, analogies or themata that are employed to describe natural and societal processes or phenomena. The use and status of such metaphors is important if one wants to come to some firm or either/or conclusion regarding whether 'nature' or the 'struggle for life' is to be characterised as co-operative or competitive. The whole question turns upon the veracity, usefulness, aptness or applicability of co-operation and competition—whether they are capable of yielding some truth-value in an absolute or scientific sense.

The first problem that is encountered is that the scientific terminology is muddled. There is absolutely nothing approaching universally accepted definitions of the various forms of co-operation, e.g. mutualism, symbiosis, phoresy, interspecific mutualism, etc. It might be tempting to put this state of affairs down to the fact that the relative lack of research in these areas, at least till fairly recently, has led to the under-development of exact or properly thought scientific nomenclature. The real problem is, however, that nature is far too dynamic and complex.

Nature is messy and is not easily pigeon holed. Symbiosis, for example, as defined by Barry, who coined the term, explicitly includes parasitism. But a Parasitologist considering the "200 million" people infected with tape worm every year "would not consider them as symbioses".[800] Experimental research shows that, in most cases "whether an organism derives benefit or harm from an association" depends upon "many factors, including environmental conditions and developmental age of the organism"[801]. Viruses invading an amoeba might at first have pathogenic effects and mostly kill the host organism. But, over the generations a relationship sometimes evolves that may result in parasitism, or, where the virus by chance provides some metabolic products advantageous to the host, some sort of

[800]Angela Douglous, *Symbiotic Interactions*, op. cit., page 1
[801] Angela Douglous, *Symbiotic Interactions*, op. cit., page 2

mutually beneficial relationship. Over time they may become virtually co-dependent. If however, environmental conditions change, the symbiont may again begin to prove detrimental or even fatal to the host. Co-operation and conflict are accidental, unconscious and relative in respect to highly variable factors outside the control and without reference to the symbiotic partners. In reality the metaphors of co-operation and conflict do not represent mutually exclusive facts of behaviour, but rather, reveal that that co-operative and competitive tendencies, capacities or aptitudes are accidental, contingent and context dependent.

Tendencies or aptitudes are not true or false and their looseness outstrips their usefulness when describing the particulars of nature. A good deal of misunderstanding arises because the human concept of co-operation, like Darwin's 'selection' metaphor, involves intentions, purposes and goals. Selection and co-operation involve a conscious act of choice with respect to attaining specific aims. People choose to co-operate with one person rather than another or, select one strain, product, type, route, etc., in preference to others in order to attain or fulfil a wide variety of specific ends, wants or needs within complex social situations. Although some human selective or co-operative behaviour results from caprice or whimsy, the notions of purposefulness, informed choice and intention are usually seen as implicit in an act of selection or co-operation. One of the problems with using human behavioural metaphors (competition, co-operation, selection etc) is that it leads confusion. Unconscious, non-intentional biological tendencies or aptitudes can only be loosely or figuratively compared with fully conscious acts of human choice.

In my opinion terms like competition and co-operation are essentially political and have gone in and out of fashion along with popular changes in social and scientific understanding. Notwithstanding the textbook description of Kropotkin as believing nature to be essentially co-operative, it must be noted that the full title of his great work upon the subject is *Mutual Aid: A Factor of Evolution*. Kropotkin did not deny the role of competitive mechanisms in nature or consider co-operation more important. Kropotkin only sought to remedy the then fashionable depiction of nature as a battlefield—a trend that he believed distorted scientific objectivity and led to false justifications of capitalism.

There are quite a number of common metaphors for society and nature (and it is of some interest that the same metaphors can be, and usually are used, to depict some aspect of both nature and society). Some of the most common nature/society metaphors other than co-operative ones include: the *web* (entangled bank, Darwin and modern ecological theory), the *battlefield* (Darwin, Forbes, Huxley), the *organism* (Spencer, Clements, Lovelock and Marguilis), the *community* (Forbes and modern ecological writing), the *body* (Hobbes and Plato), the *City* (Plato and Barbieri) and the *machine* (Paley, Forbes, Darwin). A variety of themes, all of them highly anthropocentric are drawn from technological (machines), economic (competitive capitalism), military (battlefield), physiological (body or organism), literary/artistic (entangled bank) or religious (rainforest as God's cathedral) analogies and metaphors. Although these have played an important role in characterising different approaches to (the scientific study of) natural phenomena it seems clear that from and epistemological or ontological point of view one cannot logically move from *Nature as comparable to X* to *Nature is X*.

Darwin "presented an ambiguous picture of nature". Perhaps his most insightful metaphor of nature is that of the "entangled bank". This image was variously interpreted by Darwin as "a battle field on which individuals ceaselessly struggled in the 'war of nature', and as a stable complex of interacting parts…or a 'web of complex relations'…Darwin had "two views of the living world—machinelike stability and chaotic warfare." Forbes also employed a "rich use of metaphorical language" and like Darwin described nature as a battlefield and as a machine. The community or organism metaphor was also employed by Forbes and, more significantly, by Spencer whose philosophy is centred around organismal metaphors.[802]

In evolutionary biology the individualist-competitive conception of nature predominated for nearly all of the 20th century. In stark contrast, in ecology, organismal concepts and the notion of machine-like stability predominated until the 1960's when the concepts of natural selection and non-equilibrium dynamics were introduced. The community metaphor remains however, an important concept in ecological discourse (biotic community). The organismal metaphor, despite being an

[802] Historical analysis of Darwin, Spencer, Forbes etc., drawn from Hagen's the *Entangled Bank*, op. cit., pages, 1-14. Botkin, Discordant Harmonies, op. cit., like Hagen's book is also essentially a history of environmental or ecological metaphors.

anathema to most ecologists and evolutionary biologists (who mostly prefer the systems analogy) has had something of a popular and scientific revival since the publication of Lovelock's influential Gaia Hypothesis in the 1970's. In the history of popular and scientific thinking these differing metaphors of nature and society have gone in and out of fashion along with changing political and social conditions and paradigm shifts in the various scientific disciplines.

One of Kropotkin's main intellectual rivals was Spencer, it is not therefore surprising that he rarely if ever uses organismal analogies, though he probably found them unappealing as well. Kropotkin's characterisation of nature in terms of dynamism, change and instability is essentially anti-mechanical. In this respect Kropotkin's approach is in tune with prevailing images of nature as a dynamic non-equilibrium super system.

The organismal metaphor for the biosphere has resurfaced in recent years. Likewise, machine analogies characterising the human brain or mind as a digital computer are considered as literal and self-evident truths among certain techno-reductionist artificial intelligence theorists. The idea that development is simply the read out of the genetic programme with occasional errors is similarly based upon a simplistic informatic/machine analogies.

Historically, changes in fashion have affected scientific appreciation of Kropotkin's contribution to evolutionary thought. Just when there occurred a revival of interest in Kropotkin's anarchism and co-operative biological theories in the

1960’s among political activists, there was a definite shift towards individualistic competitive models in evolutionary and ecological science.

Future discoveries in genetics and symbiosis may again challenge extreme individualist/competitive metaphors currently popular in the relevant fields. Without supporting the much stronger claim that co-operation is a more useful or more apt metaphor of nature, it is possible to seriously question the extreme individual or competitive model of nature and evolution that characterised thinking in the last quarter of the 20th century. Evolution needs to be characterised in terms of less competitive and individualistic metaphors, ones that do full justice to both the co-operative and competitive aspects of life.

In reality, however, nature is too complex. The metaphors of co-operation and conflict are not applicable at the micro-level so they can hardly be very useful as any kind of global description or living reality and it’s evolution. What is more urgently required, however, is the development of an alternative conceptual vocabulary. One that captures the complexities of nature. Darwin’s entangled bank weaved around web of complex relationships remains, an apt and surprisingly modern metaphor that captures some of the essential elements of our contemporary understanding of natural process.

Co-operation, Competition and the Inadequacy of the Information Metaphor:

Co-operative and competitive metaphors in biology have historical traditions or ideologies that cannot be reduced to the question of whether nature is co-operative or competitive. They carry with them a great many other assumptions, preconceptions and predjudices. The selfish or competitive metaphor in the hands of its chief advocates (Weismann, Dawkins etc) has accepted naïve developmental metaphors that are atomistic, centralist, hierarchical and uni-directionalist (one to one mapping) that can be characterised most appropriately in military metaphors. Kropotkin, it will be remembered, described Weismann's conception as the military unfolding of a well disciplined army or construction team involving a one way flow of information and instructions from a powerful and controlling centralist information source. According to the competitive model the individual organism is an automaton or energy vehicle programmed to replicate information. From an evolutionary point of view the competitive tradition is associated with an individual or gene-centred approach premised upon essentially static and preformist conceptions and involving the selection of micro mutations by an environment that is considered largely irrelevant. An environment that acts solely as an agent of selection or sorting. Organisms are simply war machines protecting and carrying the immortal matter or selfish genes engaged in a battle for the replication of the information contained in the controlling genes. The co-operative nature of much economic activity is reduced to a selfish urge to reproduce and is correspondingly biased towards an individualist-competitive conception of economics that dovetails comfortably with the capitalist based ideologies such theories are often used to support.

Much of the preceding analysis has shown that these auxiliary components of the competitive metaphor can be questioned or are contradicted by discoveries and theories in contemporary physics, ecology, genetics and biology. Many of these new perspectives view nature at all levels as decentralised, multi-directional, fluid, dynamic, federalist, and locally self-organised. Contained in these theories is also the modern assertion that environmental change and influence is integral to evolution and organisation of organisms. These contemporary perspectives parallel many of the auxiliary components of the co-operative tradition founded by Kropotkin but without the communistic or communalist ideology by which he was guided. This does not contradict the competitive metaphor as much vaunted aspects of capitalism is precisely that it is fluid, dynamic and flexible. The main issue it seems to me is one of control and hierarchy. Both free-market capitalism and state-communism require a state either to regulate markets or plan the economy. Kropotkin, again specifically criticised Weismann for characterising organismal development in statist terms. However according to Kropotkin's anarchistic conception stability and order are generated within a system by means of networks of headless federations involving diffuse and complex forms of *social* organisation. (note, that social is not the same as co-operation in the mutual aid sense. Competition is usually undertaken even among animals in a social context—it is social competition.

As my analysis has shown many lesser forms of co-operation involving a variety of community and social metaphors are frequently invoked by contemporary biological and physics thinkers when characterising their positions. This seems sensible to me. An alien when observing the City of London might see the stock exchange and the many other financial institutions as a huge embodiment of co-operative human effort when in fact it is the result of greed and selfishness. It all depends which level (macro or micro) is being considered. The collective rules, systems, conventions, information bases or language that regulates or facilitates development or the market do not require a strong co-operative or mutual aid explanation only an acknowledgement that their evolution and maintannce depend upon a shared or collective community of understanding and behaviour.

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