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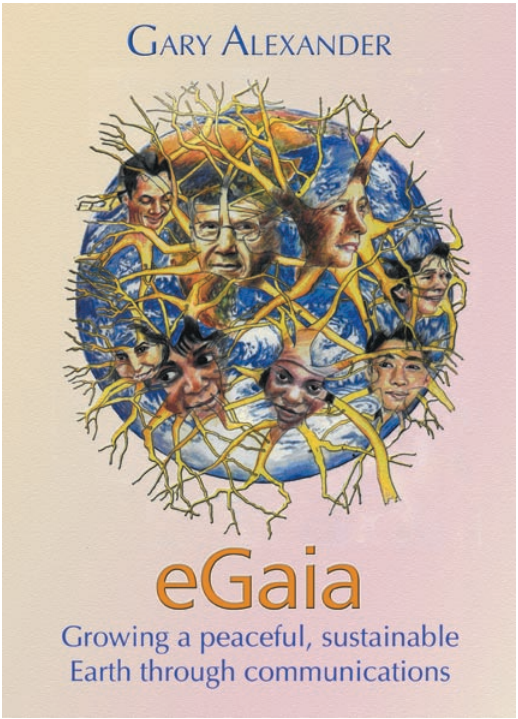


PART two

THE FIVE BILLION YEAR STORY

CHAPTER four

SYMBIOSIS AND COMPETITION: THE STORY OF LIFE ON EARTH

"We are symbionts on a symbiotic planet, and if we care to, we can find symbiosis everywhere." *Lynn Margulies*[1]

All animals (including people) continually re-form ourselves from the food we eat (which comes from other animals and plants) plus water and oxygen from the air. The plants re-form themselves from water, air and trace minerals from the soil. We complex living forms are composed of organs and tissues, which in turn are composed of cells, in turn of molecules, in turn atoms, and so on. Each level of organisation can form and re-form itself only when the conditions are right for it. Each organ has its symbiotic place in the organism, each species has its niche in the web of life. It is all one great co-operative dance. The Hindus call it the dance of Shiva. In the Middle Ages in Europe it was seen as the harmony of life. The story of life and its evolution is a mixture of symbiosis – living together – and competition.

The Whirlpool metaphor

Picture a swirl of water, perhaps in a river near an outcrop of rock. The form of the whirlpool is clear, as it dances about, changing slightly about a general shape. Take a snapshot of the whirlpool and you will see the drops of water which make it up at that instant. Perhaps a small twig or leaf will mark some drops. Another snapshot, a few seconds later, will show a similar form, some of the same drops of water but in different places, and many new drops of water. The drops become part of the whirlpool and then leave it. Through its lifetime, the whirlpool is continually re-formed from the water of the river..

This image of a form that appears constant but is actually continually re-forming from the forces in which it is embedded will be very useful to us. It applies to organisms, to ecosystems, to organisations and also to ideas and belief systems, both constructive and destructive, and thus to social and individual behaviour patterns.

With the rise of the competitive market economy and later the Darwinian theory of evolution, the competitive side of the story of life came to be emphasised out of all proportion to its contribution. Our image of nature is 'red in tooth and claw' with only the fittest surviving at the expense of the others. This image is consistent with our view of the economy. Companies compete to survive, with the weak going out of business. Similarly, in politics, parties compete in a parliamentary democracy. The strongest, the majority parties, get to impose their views on the minority.

This consistency across our views of nature, economics and politics adds to a sense that it is all for the best and inevitable. Of course we should have a competitive economy and a competitive political system. That is the most natural way, the way of nature.

But this belief is one of the keys to humanity's global cancer. It is part of the pattern by which the global cancer regenerates itself. To show that the global cancer is not actually a law of nature requires a different view of nature. The prospect of a genuinely co-operative economy, based upon symbiosis and niche-filling is not on many people's agenda. Neither is a politics where differences are respected and a consensus sought which best satisfies those different views. But these are consistent with the view of nature that is described in this chapter. The story of life is about the interplay of symbiosis and competition. Competition does have a role to play, but it is only part of the story. In a multi-cellular organism, competition between the cells is actively suppressed in favour of symbiosis. In a co-operative society, competition between ideas remains very important, but not the kinds of competition which today lead to poverty and the suppression of minorities.

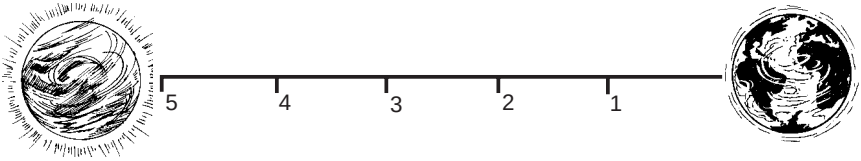
In order to build a co-operative society we will need new metaphors for what is natural. This chapter builds on the metaphors of recycling and of co-ordination of parts in an organism. A second important message that will come out of this evolutionary story is the warning lesson from the major extinctions of the past – several in the past few billion years: each time a large percentage of the Earth's living creatures died and many species went extinct. These were associated with changes in climate, very much of the sort which humanity is now triggering as one of the side effects of the global cancer.

Before life: the Hadean age

The Earth formed out of a spinning cloud of dust about 5 billion years ago. Most of that dust settled at the centre of the cloud and formed the Sun. The material of the Sun – mostly hydrogen – contracted and became hotter until the Sun ignited in a thermonuclear reaction that continues today. The remainder of the cloud (only a fraction of a per cent of the total), dispersed over hundreds of millions of miles, settled into a disk, and then into clumps. The largest of these clumps formed the nine major planets – Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune, and Pluto, spinning around the Sun in elliptical orbits.

The Sun is far too hot for anything solid to form. The planets are too small to burn like the Sun. For the complex molecules that make up life to form, the right materials had to be present, under the right conditions. The outer planets were always far too cold. The innermost planets – Mercury and Venus – were probably always too hot. Earth and Mars were the only two which ever came close.

The five billion year story



Billion years ago...

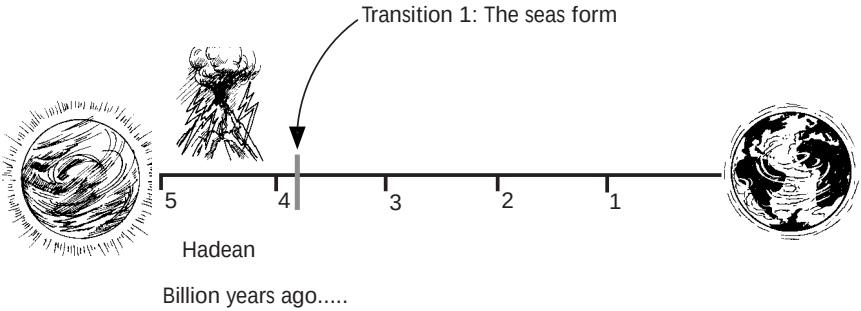
The conditions on the early Earth were totally unlike the present. Much of the surface was volcanic and the surface was too hot to allow any oceans. Any rain that hit the surface boiled away immediately. The atmosphere was largely carbon dioxide, like Mars and Venus today. Oxygen, so vital to life

The Hadean age[2]

now, wasn't there. The present conditions on Earth co-evolved with life over the billions of years since. Life has not been a passive passenger on Earth, but has been a major shaper and maintainer of the conditions it needed.

This period[3] before life is called the Hadean Age and fits well with the classical images of Hell. Eventually, the Earth cooled until its surface temperature dropped below the boiling point of water. The rains fell for millions of years and the seas were formed. The earliest sedimentary rocks date from this time.

The first part of the Five Billion Year Story was the Hadean age



First life: the Archaen age

When the seas had formed and the Earth was cool enough, conditions soon became suitable for the formation of the earliest forms of life. And life did form almost as soon as it became possible – within a few hundred million years.

You You call a few hundred million years soon?

Me On these time scales, yes.

Those early seas are what we call the primordial soup. The seas and the atmosphere contained molecules that were simple combinations of hydrogen, oxygen, nitrogen and sulphur that later came to make up most of the components of life. Local micro-environments formed where conditions were more stable and in which larger molecules could form. Simpler molecules were continually forming more complex molecules and breaking up again to form simpler molecules, their links forged and destroyed by the energy of the Sun. For example, molecules of hydrogen cyanide (one hydrogen atom, one carbon atom and one nitrogen atom – HCN) could form a chain by connecting to itself five times. The result is adenine ($H_5C_5N_5$), one of the main components of the genetic material, DNA.

Some of these molecules turned out to be catalysts: they acted as templates on which other molecules assembled to form larger, more complex molecules. In effect, the template formed a map of the structure of the molecule it helped to form With a template, the molecule could assemble much more readily.

Chains of reactions began, where the results of some reactions were the starting materials for other reactions, whose results were the starting materials for still other reactions, and so on. Eventually, some chains of

reactions appeared which were closed: the results of the last reaction were the starting materials needed for the first one, so the chain could start again. By this point, life was not far away. The other necessary component for life was the membrane: a molecular net with holes that allowed some materials through and blocked others. The earliest of these were simple repeated assemblies of molecules, formed by chains of molecules sticking to each other.

Molecules, closed chain reactions and membranes are the elements of a rudimentary cell. This was the forerunner of today's bacteria, and the basis of all later life. Those first cells can be seen as the beginnings of symbiosis on a molecular level. Each component was needed for the continuation of the others.

There is much more to the story before a bacteria-like cell appeared, but that is the start of it. The membrane had to allow in any raw materials not created by the cycle of reactions and allow out any by-products not used in them. The templates had to be able to re-form not only themselves but also the membrane. The whole had to be sufficiently robust so as to be able to re-form itself against damage caused by the continually changing micro-environment.

You So that's the secret of life! Are you sure about all this?

Me No, but it's the best we have. Almost none of it is based on direct evidence. It comes from a combination of laboratory experiments, mathematical and computer simulations, and a lot of theoretical speculation. It is all other people's work, and the details of it are way beyond my understanding. There are great gaps in it, but it seems plausible. More important, the patterns and processes I've been describing here are similar to others which will appear later in the book. I'm hoping to

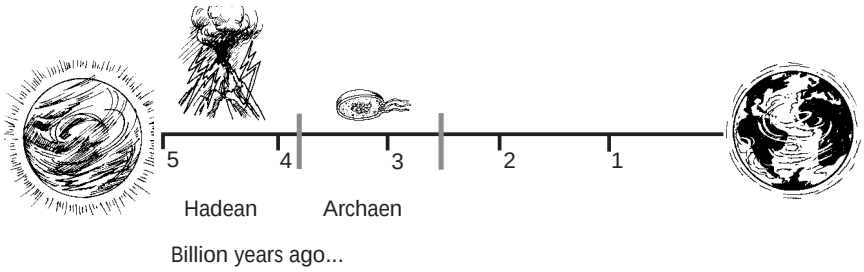
show you a grand pattern, whose consistency on many levels will add to its overall plausibility.

These primitive cells show a whirlpool-like pattern – a form that is continually re-formed from a surrounding sea of its parts. With a cell, however, there is an important extra – the templates: the genetic material, the RNA and DNA, which appears in every cell in all living creatures. They provide a description of the essentials of the structure of the cell. It is that description that gives the cell the coherence that maintains its wholeness. The information in that description is crucial to the maintenance of the form of the cell. As we will see later in the book, it is similar to the use of information and communications to maintain the form of a co-operative eGaian society.

The symbiotic bacterial lifestyle

The earliest forms of life developed from primitive proto-bacteria to full bacteria over an extended period following the formation of the seas, and it was still longer before any more complex life evolved. This period, when bacteria were the only form of life, is called the Archaen, meaning ancient or beginning.

The first life appeared in the Archaen period



Bacteria are very simple cells; plant and animal cells are much more complex, with a separate nucleus where most of the genetic material is contained, internal membranes, and numerous small internal structures called organelles. Plant and animal cells also reproduce differently from bacteria. To understand the development of these more complex cells, we first have to look more closely at the life of bacteria.

You Just a minute. Surely bacteria are either plants or animals? Are you saying they are something different?

Me Yes. The old idea that life falls into two kingdoms – plants and animals – is now obsolete. There are many creatures that do not fit comfortably into those two categories. The modern division is between cells with and without a nucleus. Those without are the bacteria. They evolved first, in the Archaen, nearly 4 billion years ago. Plants, animals and fungi came very much later, less than 500 million years ago.

A bacterium contains a minimal set of genetic material, barely more than needed to re-form itself and reproduce. Yet bacteria are extremely adaptable. They can survive an amazing range of environments – nearly boiling waters, airless conditions, and environments that would be poisonous to any other creatures. They adapt rapidly to changes in their environment, as is clear from the way they have developed resistance to many antibiotics. How does this happen? Margulies and Sagan give a vivid description[4]:

> "Its minimal number of genes leaving it deficient in metabolic abilities, a bacterium is necessarily a team player. A bacterium never functions as a single individual in nature. Instead, in any given ecological niche, teams of several kinds of bacteria live together, responding to and reforming the environment, aiding each other

> with complementary enzymes. The various kinds of bacteria in the team, each present in enormous numbers of copies, co-ordinate the release of their enzymes according to the stages in a task. Their life cycles interlock, the waste products of one kind becoming the food sources of the next. In huge and changing numbers, they perform tasks of which individually they are incapable."

So bacteria can be seen as inherently symbiotic creatures. Living together is an essential part of their lifestyle. This resembles the complementary nature of the reactions within each bacterium, with different reactions contributing materials needed by others and using the results of others.

In bacteria, reproduction and sex are completely separate. A bacterium reproduces by growing to twice its normal size, when its single strand of DNA duplicates itself and the cell splits into two identical cells. The daughter cells are genetically identical to the single parent (which no longer exists).

Sex is the exchange of genetic material. Many mechanisms are available for this. Two bacteria may combine into one, which ends up with all the genetic material. Or bacteria may exchange genetic material through a small tube that forms temporarily to join them (called conjugation). Also, small bits of genetic material may get packaged up in various ways and travel between bacteria. These packages include plasmids, phages and viruses. Viruses, which can be so deadly to creatures with complex nucleated cells like us, are not a separate form of life, but a normal part of the sexual repertoire of bacteria.

In plants and animals, the genetic material in one generation is very much like that in the previous generation. The form of successive generations changes very little within any species. Bacteria are much more fluid. They are continually changing their form and their genetic material, often very radically. This is how resistance to drugs can develop so rapidly.

You Why this prurient interest in the sex lives of bacteria?

Me You may joke, but this is a crucial point. One of the aims of this chapter is to squash the idea that competition is the basic organising principle of nature. It's clear already that to explain the behaviour of bacteria in terms of competition is to leave out most of what is significant.

The lives of bacteria are totally interconnected and interdependent. Their response to changing conditions is that of a group. By modifying the mixture of metabolisms available they adapt as needed. Because of their genetic fluidity, there is a sense in which all the bacteria on Earth can be viewed as a single species; because of their group interdependence, they can even be viewed as a single, global super-organism[5]. To see individual bacteria competing with each other is to misunderstand the nature of their lives. An individual bacterium's fitness to survive depends upon the adaptability of the local colony of bacteria around it.

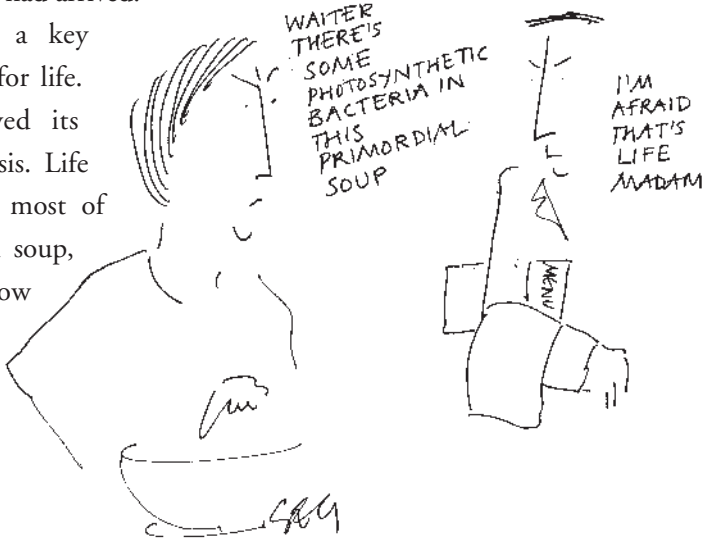
The earliest bacterial colonies fed on the most readily available molecules in the primordial soup – carbohydrates and alcohols. This is the metabolism of a fermenter. These early forms of metabolism are still with us in the modern bacteria that make our cheese and wine and which live in the guts of most animals and form a vital part of the animals' digestive system. There were many different forms of fermenter, with different metabolisms. In any colony, one fermenter's waste was another's food, so that the basic materials were recycled. Recycling and re-use of materials has been a basic principle of life from the start.

As the early baterial colonies grew and spread, more and more of the available materials became incorporated into their bodies. Over time, many new metabolic pathways were developed enabling spreading life to eat up more and more of the primordial soup. There must have been many local

crises, where no more soup was available and colonies died out. There must also have been many times when, under this pressure, a new metabolic pathway was discovered, and a new source of food allowed the colony to continue. Through the Archaen age, nearly all the metabolic pathways used by bacteria today evolved, and these are the building blocks of the metabolisms of all the more complex forms of life.

One particularly important metabolism was photosynthesis, in which sunlight was the energy source. The earliest photosynthetic bacteria were sulfur breathers. They gave off hydrogen sulfide (the gas which gives rotten eggs their smell). A later form of photosynthesizer used carbon dioxide gas, which was abundant in the air and dissolved in the surface of the early seas. Carbon dioxide and water itself provided most of the materials needed. These bacteria extracted carbon from carbon dioxide and hydrogen from water and used them to build the molecules they needed, giving off oxygen as their waste product. Thus the major metabolic pathway used by all modern plants had arrived.

This was a key breakthrough for life. It had resolved its first major crisis. Life had eaten up most of the primordial soup, but could now continue to grow with carbon dioxide as its food.



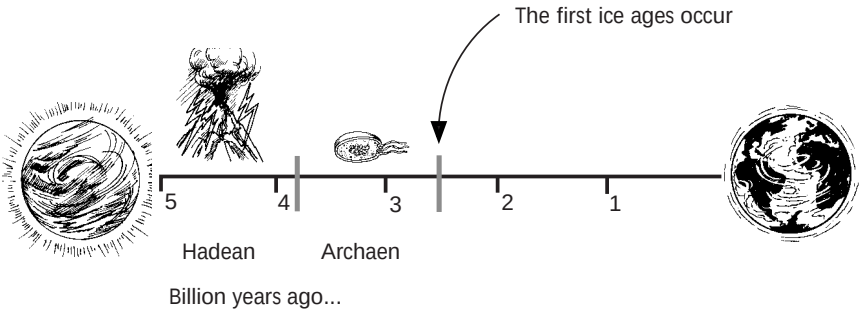
You Are you saying that photosynthetic bacteria replaced all the others?

Me Not at all. Remember interdependence, interconnectedness and recycling. All the others could continue too.

This was the beginning of the dramatic changes life was to make to the Earth. It had eaten up the soup, turning it into bacteria, and was now beginning to change the atmosphere. The long process of change had begun, from an atmosphere composed mostly of carbon dioxide to today's atmosphere which contains only 0.03% carbon dioxide. This time also marked the first great environmental crisis to hit life.

Today, we hear about carbon dioxide as a greenhouse gas; its increase leading to global warming. In the late Archaen age carbon dioxide levels fell and the world cooled, to give the first ice age. This event is a rough marker of the end of the Archaen age and the beginning of the Proterozoic.

The first ice ages roughly mark the end of the Archaen age



Life in the late Archaen / early Proterozoic age

"To a casual observer, the early Proterozoic world would have looked largely flat and damp, an alien yet familiar landscape, with volcanoes smoking in the background and shallow, brilliantly colored pools abounding and mysterious greenish and brownish patches of scum floating on the waters, stuck to the banks of rivers, tinting the damp soils like fine molds. A ruddy sheen would coat the stench-filled waters.

Shrunk to microscopic perspective, a fantastic landscape of bobbing purple, aquamarine, red, and yellow spheres would come into view. Inside the violet spheres of Thiocapsa, suspended yellow globules of sulfur would emit bubbles of skunky gas. Colonies of ensheathed viscous organisms would stretch to the horizon. One end stuck to rocks, the other ends of some bacteria would insinuate themselves inside tiny cracks and begin to penetrate the rock itself. Long skinny filaments would leave the pack of their brethren, gliding by slowly, searching for a better place in the sun. Squiggling bacterial whips shaped like corkscrews or fusili pasta would dart by. Multicellular filaments and tacky, textilelike crowds of bacterial cells would wave with the currents, coating pebbles with brilliant shades of red, pink, yellow, and green. Showers of spores, blown by breezes, would splash and crash against the vast frontier of low-lying muds and waters."[6]

Complex cells: the Proterozoic age

Early photosynthetic bacteria gave off oxygen as well as taking in carbon dioxide. Oxygen was not present in significant quantities in the early atmosphere. It is too reactive: it combined so readily with many other substances that it did not persist as free oxygen. For a long time, rocks rapidly absorbed the oxygen produced by the early photosynthesizers. Some ancient banded iron rocks containing layers of iron oxide have been found, which are evidence for this process. Much of our present iron ore dates from this time.

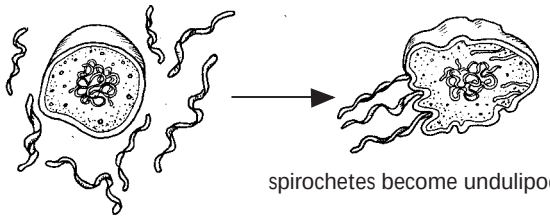
Eventually, the oxygen given off by bacteria was more than could be absorbed, and it began to build up in the atmosphere. While to us oxygen is vital and a key to life, to the bacteria in the late Archaen it was a deadly poison. The reactivity of oxygen destroyed cells. The build-up of oxygen in the late Archaen was the greatest pollution crisis life on Earth has ever faced.

Major crises require radical solutions. The outcome of the oxygen crisis was the development of the eukaryotic cell – a new compound cell with a nucleus. Those cells now form the basis of all animals and plants. Their development marked the major division in life forms.

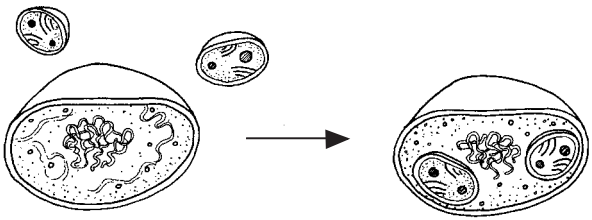
How did it happen? As oxygen began to accumulate in the Earth's atmosphere, and also dissolved in the sea waters, certain bacteria evolved which, rather than being killed by it, made good use of it. Some forms of *cyanobacteria*, one of the early photosynthesizers, learned the trick of using oxygen in a form of internal, controlled combustion as a source of energy. This was the beginning of respiration. These bacteria could take in oxygen and give off carbon dioxide. This trick not only protected *cyanobacteria* from the ravages of oxygen, it was also a very efficient form of metabolism compared with that of the earlier fermenters. *Cyanobacteria* thrived. Many

new oxygen-using forms developed from them. They quickly replaced the oxygen-sensitive bacteria on the oxygen-rich surface, while other bacteria survived underneath them in the lower levels of mud and water.

The stage was also now set for the development of the compound cell. It is known that small bacteria can live independently yet symbiotically inside larger cells. The smaller bacteria find plentiful food inside the host, and their metabolism contributes to that of the host. In some cases, the invader might have started as a predator. Some hosts did not die, and developed not a resistance, but a need for their new partner. Margulies believes that the first step towards the complex cell was a merger between a swimming bacterium and a fermenting bacterium. This is the ancestral symbiotic cell, and makes up most of the modern cell. Next was a respiring bacteria, *paracocci*.[7]



spirochetes become undulipodia



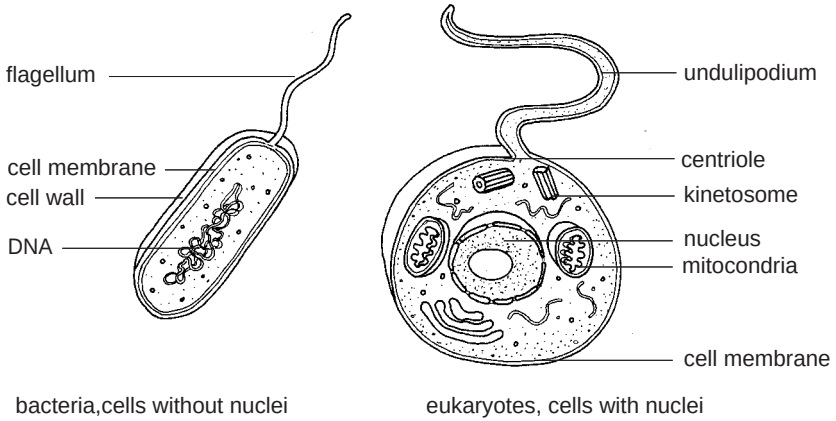
cyanobacterium and aerobic bacterium
combine in symbyotic relationship

In the midst of the oxygen crisis, this symbiotic arrangement, with oxygen-using bacteria inside, proved very attractive to some. It was the safe place to be in the new, oxygen-rich world. Symbiotic colonies of bacteria began to evolve which could use oxygen and which combined the strengths of their various members. In a modern eurkaryotic cell, the oxygen-using part is an organelle called a mitochondrian. Mitochondria today retain many of the characteristics of free-living bacteria. Their internal structure and chemistry is very similar to that of some bacteria.

Other cell structures are like this too. Plant cells contain choloroplasts, the sites of photosynthesis. They also have their own DNA, reproduce independently, and are nearly identical to a bacterium called *prochloron*.

The evolution of the eukaryotic cell starts as a colony of bacteria, living a symbiotic life for mutual benefit. Over time, the internal structure changed, with much of the genetic material coming together into a central nucleus. The process by which the DNA in the nucleus of a eukaryotic cell divides is much more complex than in a bacterium. The details of this division are aided by structures that also might have had bacterial origins.

Procaryotic and eukaryotic cells campared[9]



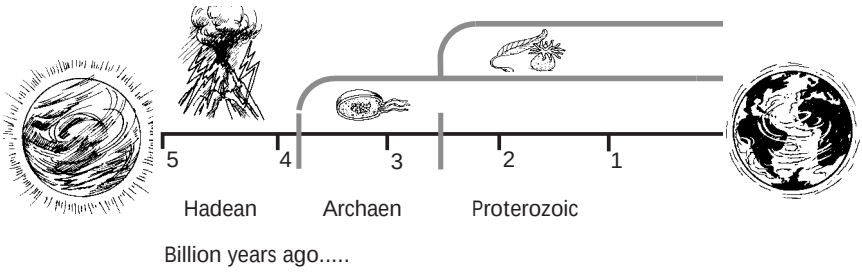
The new large nucleus now contained most of the cell's genes. That is, it contained most of the templates needed to build the molecules from which the parts of the cell were made. Again, this provided a description of the cell that was the key to the maintenance of its wholeness.

This, perhaps, is the story of the greatest step in life's evolution. It is certainly clear that those new organisms that exploited oxygen survived much better than those that could not. The descendants of the latter now remain mostly in specialised environments, including our guts. But symbiosis was the key to the emergence of a new level of the organisation of life.

These new, more complex cells had some striking advantages over bacteria. Some were much more mobile. They contained undulating hair-like protrusions to propel them along. These are likely to have evolved from spirochaetes, whip-like bacteria with similar properties. This mobility and their larger size helped in gathering food. Their extra complexity enabled them to cope with a wider range of conditions.

These new creatures flourished. For about two billion years, until the animals, plants and fungi developed, they and the bacteria were the only forms of life. Those creatures that have cells with nuclei but are not animals, plants or fungi are called protists.

The Proterozoic age followed the Archaen age. Both bacteria and protists flourished



Many of the protists are single-celled creatures, like amoeba and paramecium. But some are also multi-cellular, like slime molds, seaweeds, kelp and sponges. (In fact there are multi-cellular forms of bacteria too.) These multi-cellular forms generally develop as clones of a single cell. There is very little specialisation of cells, unlike the plants and animals that were still to come.

You And isn't a multi-cellular creature also a form of collaboration rather than competition?

Me Exactly.

Multi-cellular forms, too, had many advantages, with their size contributing to the stability of their local environment. For a cell that is part of a multi-cellular form, much of importance in its local environment consists of its sibling cells. By enhancing the survival of its local environment, the cell enhances its own survival. It is an example of life co-evolving with its environment so that the life form and local environment become closely matched.

Complex creatures: the Phanerozoic age

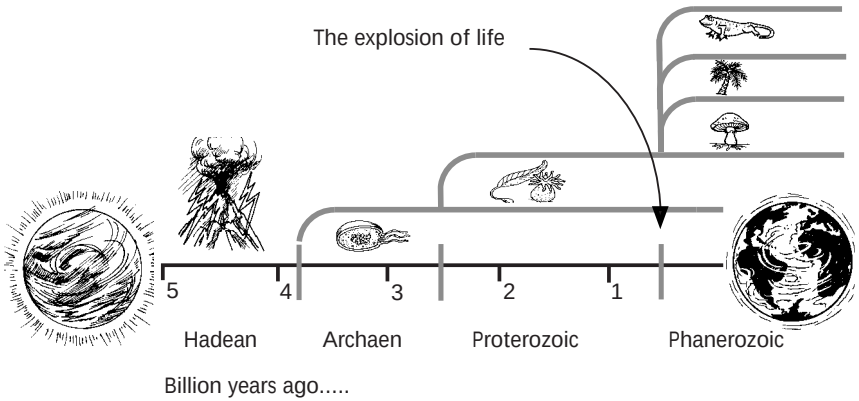
The story moves on to the final part, the last 570 million years out of 5 billion, when most of the standard evolutionary story took place. It is the story of life as told mainly by the fossil record. Most of the earlier parts have been discovered only within the last few decades. That earlier life left no fossils, and its discovery awaited the development of more subtle techniques.

As the Proterozoic age drew to its close, oxygen began to build up towards modern levels. High in the stratosphere, ultraviolet radiation turned some of that oxygen into ozone. (Oxygen molecules normally consist of two oxygen atoms; ozone molecules are made up of three oxygen

atoms.) This layer of ozone then absorbed most of the ultraviolet, creating a shield that protected life, and made possible its spread onto land.

As oxygen built up, carbon dioxide levels fell still further. The Earth cooled; another ice age followed. A major change in the geological record marks this point. After it, life proliferated as never before, now onto land as well as in the seas. Creatures with hard body parts evolved and so fossils began to appear. This is the Phanerozoic age.

The explosion of life began around 570 million years ago



Biologists now divide life into five kingdoms: bacteria, protists, fungi, plants and animals. By the beginning of the Phanerozoic, the first two of these were well established. In the Phanerozoic, multi-cellular forms of protists evolved into the fungi, plants and animals. All of them (and that includes all of us) are really symbiotic colonies of cells, which in turn are symbiotic colonies of bacteria. The three new kingdoms each developed as expressions of a new and specialised life strategy.

The fungi specialise in external digestion. They give off chemicals that transform some of what is around them into the chemicals they need as

food, which they then absorb. They often live in a symbiotic relationship with plants, supplying the nitrogen and phosphorus the plants need. Plants use sunlight as an energy source to enable them to build themselves, mostly out of carbon dioxide and water. They give off oxygen as a by-product. Animals take in oxygen and use it in a controlled combustion process as an energy source, with carbon dioxide as a by-product. Animals generally need fairly complex chemicals (carbohydrates, proteins and fats) as the starting points for forming and re-forming themselves. To get these chemicals, they eat plants, animals or animal waste products. Their waste products and dead bodies also feed the plants, fungi, bacteria and protists.

The parts go round and round. Oxygen and carbon dioxide are cycled between plants and animals. Some creatures build up bigger bodies from simpler parts. Some creatures turn the bodies of other creatures back into their simpler parts. Bacteria, protists, fungi, plants and animals are all intricately enmeshed in this. It is a grand whirlpool pattern made up of smaller whirlpool patterns made up of still smaller whirlpool patterns.

Recycling is the essence of the pattern of life. It started at a local level with the bacteria. The possibilities expanded with new forms of bacteria and then protists. With the development of fungi, plants and animals, many new pathways opened along which the parts could be recycled. As a result, the total mass of life on Earth expanded tremendously – the explosion of life.

Early in their evolution, plants developed a form of sexual reproduction more familiar to us. Some of their cells divided in half without first doubling the genes within them, so that each of the new cells had only half the complement of genes. These then combined with similar cells from another individual. The result was a cell with the full amount of genetic material, half from one parent and half from the other.

This sexual reproduction from specialised cells was part of a general pattern, where plants came to be made up of parts whose cells were specialised for different functions – roots, stems, seeds, leaves and ultimately flowers. Each individual now was a symbiotic colony of parts, each of which supported the others in its own way. This specialisation allowed greater variety in life strategies: leaves could catch the light while roots absorbed water from under the ground.

Maintaining wholeness

The first cells, the bacteria, had a wholeness that was more than a whirlpool-like unity because they had genetic material that acted as templates for the molecules of which they were made. In the more complex eukaryotic cells, the templates, the genetic material, are mostly concentrated in the nucleus. Again, they provide the description that maintains the wholeness of the eukaryotic cell.

Multi-celled creatures with specialised cells involve another level of description. The specialised cells within one creature can be very different. In plants, the difference between pollen, petal, leaf, bark, and root is striking. Yet it is as nothing compared to the difference between cells in animals: white blood cells are similar to amoeba while bone cells are more like a tree trunk. Nerve cells, skin cells, muscle cells, light sensitive cells in the eye – all are so different that in isolation they might be thought totally unrelated.

All the cells in a multi-cellular creature contain

identical genetic material, but only some is used in each type of cell. Only the templates for the parts needed for that cell are active. It is as though the genes for many different creatures were combined in one place, but with only some of them switched on at any one time. The next level of description of a multi-cellular creature is that which determines which genes are switched on and off in a particular cell. The switching on and off of genes is an essential part of the functioning of an organism, beyond just the growth and specialisation of the cells. Switching on a gene means that the chemical for which it is a template gets produced. It is largely under the control of hormones, which are a set of chemicals which circulate through an organism, as a general control system.

At any of these levels of wholeness – bacteria, eukaryotic cell, or multi-cellular organism – co-ordination at an overall level replaces any competition between the parts. Where it fails you get disease, as cancer is growth out of control of the whole.

The earliest plants were the mosses and liverworts. Ferns with seeds followed them. These were the first land plants. They formed the first forests between 345 and 225 million years ago. Our modern coal fields are the remains of some of those early forests, showing that the recycling was not complete. By burning that coal today we are returning carbon dioxide to the atmosphere which was removed from it by those forests when they were alive.

The first conifers appeared about 225 million years ago. They relied on the weather to distribute their seeds. The first flowering plants appeared about 123 million years ago. They evolved together with the insects in a symbiosis in which flowers attract the insects to the nectar within, and in the process of travelling from plant to plant, the insects pollinate the plants.

Animals, like plants, are complex symbiotic colonies of specialised cells. The distinction that is now made between animal-like, multi-celled protists and what are now considered true animals was that the latter developed from an embryo. Another key feature of true animals is sophisticated communication between cells, particularly through a nervous system. The combination of nerve cells and muscle cells allowed synchronised contraction of the muscle cells to produce co-ordinated movement. The combination of nerve cells and cells that responded to light or to chemicals in the water or air gave sight, smell and taste.

These organisms provide useful metaphors for the kinds of co-operative societies dealt with later. They have a variety of parts, each working together in their own way for the better survival of the whole, with competition between the parts suppressed. Their common wholeness is described in the templates – the genetic material that is the same in each cell but expressed differently in different cells. They have a communication system to help them identify problems and solve them in a co-ordinated manner.

The earliest animals were some primitive worms, dating from about 700 million years ago, actually before the start of the Phanerozoic age. From these came the segmented worms, then the other segmented creatures, like those with external skeletons (trilobites, crabs, shrimp, insects and spiders). From some of the segmented worms developed creatures with a chord of nerves running through their length. When this became encased in bone it formed the first spinal chord, and from this

came the fish (513 million years ago), then the amphibians (345 million years), the reptiles (245 million years) and finally the mammals and the birds (210 million years). Over time the mixture of creatures changed. The parts were rearranged in different ways. New pathways along which the parts were cycled arose while old ones disappeared.

Catastrophe and diversity

The changes in the mixture of life forms was not usually smooth. The pattern of the Archaen and Proterozoic ages – crises followed by the emergence of new forms – appears to be the normal pattern. The Phanerozoic, too, is marked by massive crises, sudden great extinctions when a large proportion of the life forms vanished, followed by the development of new forms.

About 250 million years ago there was a massive extinction which killed off 90% of all species of life.[10] Although the causes aren't too clear, it seems that there was a slow decline in species for a few million years before it, and then a sudden catastrophic event. There was slow climatic change caused by the coming together of some of the continents. This also resulted in a period of huge volcanic activity that released vast amounts of carbon dioxide. The carbon dioxide in the seas was a direct killer, but it also led to a sudden temperature rise of 5–10°C. That was the catastrophe which did most of the killing.

You Shades of today's fears of global warming.

Me Exactly.

This catastrophe marks the start of the Triassic period in the geological record. It took millions of years to re-stock the land and the seas. Even the 10% of species that survived were severely depleted. The few survivors

found themselves in a wide-open world with very little competition, so they flourished and diversified into the new niches. This was a good time for reptiles, and the first dinosaurs appeared. The first true mammals also appeared at this time, but mostly they were small insectivores and tree dwellers.

There was another mass extinction at the end of the Triassic, 200 million years ago. Although not as severe as the one which started it, it is still one of the big five extinctions. Again, it seems that a series of environmental problems, like big volcanic eruptions, led up to it. This time the final catastrophe seems to have been triggered by a four or five-mile-wide meteor colliding with the Earth, forming the 70-mile-wide Manicouagan Crater in Quebec.

This extinction event marks the end of the Triassic and the start of the Jurassic period. The aftermath was that the dinosaurs became the dominant land animals. It took the two major mass extinctions for this to come about. They weathered the extinction with only modest losses and were dominant for about 120 million years until the mass extinction event 65 million years ago.

The final cause of that extinction was a now notorious meteor or comet. It was at least six miles in diameter and hit the Earth in the sea near Yucatan, Mexico, creating a 180-mile-wide crater and massive tidal waves. More than half the Earth's vegetation burned in the weeks after the impact. Acid rain made the seas too acid for much life, and global warming resulted from the release of carbon dioxide. Even before this time, though, many species were already in decline or were going extinct. It seems that there were three separate causes: climate change from carbon dioxide emissions, sea level change and then the meteor.

The mass extinction event 65 million years ago killed off most of the

dinosaurs, leaving as their only descendents the birds. A few mammals also survived and went on to become the dominant form of life. They went through a burst of evolution, starting with a load of very small mammals. Then, about 40 million years ago, the Earth cooled, leading to the spread of grasslands that favoured the evolution of large mammals. There were many giant mammals: many elephant species, mammoths and mastodons, giant camels and enormous ground sloths, giant dogs, cats and bears too. By about six million years ago, the world appeared nearly in the form that it was in when humanity evolved.

The final chapter in the story of life starts about 2.5 million years ago. Again, a variety of events led to more cooling, and the Earth entered a period of ice ages. Since then the climate has oscillated between longer ice ages and briefer inter-glacial periods. This cooling brought about a pulse of extinctions. The modern extinction started then. Again, it started with climate change a few million years before the major event that provided the *coup de grâce*. Thirty per cent of North American land mammals went extinct at the onset of the ice age. However, the knockout punch for the larger mammals was delivered about 11,000 years ago, when two-thirds of North and South America's larger mammals suddenly disappeared over a period of about 1,000 years. This coincided with the arrival of humans in the Americas. It was the first chapter in the story of humanity as a global cancer.

You Doesn't all this talk of extinctions and survivors mean that at a time of crisis the fittest survive? And you keep writing about symbiosis, but you barely mention competition and survival of the fittest. Surely you aren't just going to ignore them?

Me I think I've spelled out enough of the history so that I can tackle this issue of competition and fitness directly now. Just

for starters, I'll answer your first question. At a time of crisis the meaning of fitness changes, so different creatures survive than survived before it.

Symbiosis and competition

By now the intricate interconnectedness of life is very clear. All creatures rely on many others to provide their food and shelter, decompose the accumulated rubbish all create, and generally provide the rest of all the cycles of which they are part. The environment for each is all of the rest. The life cycle of any creature cannot be understood without understanding its environment. All creatures are simultaneously separate individuals and parts of a larger whole.

From this perspective, fitness means fitting in the sense that a piece in a jigsaw puzzle fits into the hole left for it. That hole is the particular way of life, the niche, of that individual. Fitness certainly does not mean a general superiority of one creature over another. A niche can also be seen as an opportunity, a possible way of living for something. An organism evolves and finds its place in its conversation with its environment. The niche is the other side of that conversation.

Under normal conditions, when there is no crisis in progress, virtually all the niches available get filled. In natural grassland there will be a mixture of grazing animals, each with somewhat different teeth and digestive systems so they can eat different mixtures of the vegetation. There will be different birds, each with differently shaped beaks specialised to eating different sizes of insects, or those that live at different depths under the surface. There will be some animals specialised to feed on virtually every one of the plants and some predators and parasites that eat virtually all of the animals.

Of course, the jigsaw puzzle analogy is somewhat limited. The edges of the biological holes are not sharp as in the puzzle. There is a certain amount of overlap between the niches of one creature and another. It is in these areas of overlap that competition comes into play. It provides a jostling for position that clarifies this overlap and leaves the niches more distinct.

You You are giving competition a very marginal role then?

Me Well it's a very important role. The interconnections and symbiosis determine the overall shape of the pattern, the mixture of creatures and how they live. The clarity with which the parts of this pattern fit together; the closeness of the fit, comes from competition. That is what I understand by survival of the fittest.

Another limitation of the jigsaw puzzle analogy is that the shapes are fixed, while biological niches are continually changing. With no environmental crisis, the changes are small and slow. Creatures become highly specialised, very closely adapted to the conditions around them, their food species, symbiotic species, predators and so on. Then along comes a crisis: the primordial soup runs out, oxygen begins to appear, an ice age begins or ends, a mass extinction event occurs or maybe it is something much smaller and more local. Then the shape of all the holes changes. The niches are no longer what they were. The intricate web of support is rendered. It is no good being a mighty dinosaur, capable of killing any large animal around, and especially those puny little mammals. If the food of your food goes, you go too. In a crisis, the fitness of an individual animal or species is not relevant. It is the set of relationships in the whole ecosystem around it that counts.

After a crisis there is no longer as close a matching of life forms. New pathways become available. New strategies for living can emerge. A crisis

favours generalists, creatures which can feed off a wide range of others or who can live in varied conditions. There is a rapid development of new forms of life.

You Perhaps there is a lesson in there for us. If the global cancer triggers a major crisis, then generalist groups and individuals will have an advantage.

Me Yes.

Under the new conditions, some creatures find they have some very useful abilities, perhaps developed for another purpose. Fish living in shallow shore waters who learned to breathe air a little and use their fins to push along the bottom might find they could survive on land a little. They are already adapted to the new conditions. At first the new forms don't have to be very well adapted to the conditions. The first land animals couldn't walk very well. The first birds couldn't fly very well. Competitive pressures soon sort out a new set of niches with specialised, well-adapted creatures. As walking or flying predators appeared, their prey learned to run and fly fast. As the new set of niches becomes filled, change slows down and a normal period arrives.

You I think I'm beginning to get the idea. You aren't saying that competition isn't important, just that this symbiosis business and being part of the web of life is actually the major part of what counts.

Me Yes, that's right. The image of nature as a war is a projection onto nature of a market economic system! It is very recent, only appearing since Darwin in the last century. It replaced a projection of feudalism onto nature, 'God's harmony' with everything in its hierarchical place.

You Aren't you trying to create a projection onto nature of your view of society? What is nature really like?

Me I suppose that is what I am doing (although it's not just my view). What is nature really like? I suppose a sage would say that nature 'just is'.

You I'm not completely satisfied yet. Can we go back to competition? What about the competition between male animals for dominance or access to females? Surely that is a major part of their life?

Me OK. Within one species the same principles apply, and we can sometimes even begin to glimpse another level of organisation.

Within one species the overlap between niches is especially strong. All the foxes in a wood eat the same prey. All the rabbits like the same plants. What generally happens is that the niches for creatures of the same species are geographic. Individuals or groups have their own territories within which there is sufficient to meet their needs. Competition again appears at the boundaries of the territories. Birds sing in large part to say "this is my territory."

For many animals, other members of their own species are of major importance in their environment. At the very least, they need them to mate. Thus it is not surprising that when competition arises between members of a species, it is usually minimised. Often there is a ritual or rule that determines which creature wins. With certain butterflies, the first one on a particular leaf has priority. With many animals threatening postures are enough to see off a rival.

The issue between two rival animals is to see which one gets to mate, or gets the territory. This is a matter of communication between creatures

with very limited means of communication. If the appropriate criterion is the size and showiness of your tail feathers, then a display will settle the issue. If it is a matter of strength, then a fight is needed. However, animal fights rarely end in death or serious injury. They generally end when it is clear who will win.

It is striking how many different animals live in groups: flocks, herds, schools, prides, or whatever. For these animals, the benefits of being in a group clearly outweigh competitive pressures from sharing a niche. Being part of a group can give protection from predators (grazing animals), help with care of offspring (lions), co-operation in hunting (dogs). Some of the social insects have very specialised forms. An individual ant or termite is hardly a separate creature. It may be able to gather food, or produce eggs or defend the colony, but not any of the other tasks. It is more like a cell in the super-organism that is the colony.

Imagine you are watching a large flock of starlings, several hundred birds. You notice a main group and various smaller groups, constantly changing. A few birds circle high in the air watching for predators. One or two take off to the next field to search for food. A few more peel off from the main group to join them. If they are successful and settle onto that field, others will see them and join them and soon the bulk of the flock will leave its present location and join them. If the watchers signal danger (you perhaps), the whole lot will suddenly take off and fly away.

Birds are the ultimate symbol of freedom. None of those starlings tells any of the others what to do. They live in a flock, choosing their roles from moment to moment in support of the flock, synchronising their behaviour with each other, because that is what it is to be a starling. Freedom and collaboration are in no sense in conflict with one another.

CHAPTER five

THE CO-OPERATIVE APE: THE EARLY HUMAN STORY

The last chapter set a context for humanity. Now it is time to look at what it means to be human. The last chapter dispelled the myth that the natural world is inherently competitive and warlike. This one does the same for humanity.

Today it is very common for people to find themselves in situations where the appropriate response seems competitive or warlike rather than co-operative. People have become very skilled at being competitive. Our most sophisticated technology is that of war. But human history suggests that this has been the case only since the advent of what we call civilisation – very recent in our evolutionary story. This chapter will trace this aspect of humanity's history. The story is of an animal whose niche, whose speciality, was working in co-operation within small social bands, sharing food which had been gathered and hunted, sharing child care, learning from their ancestors' experience, etc. Our big brains, languages and

cultures evolved to make this possible. Our physiology and personalities evolved as animals who were co-ordinating their group actions well beyond that of any other mammals.

Origins

In the family tree of life, humans are on the mammalian branch, which appeared some 210 million years ago. We are part of the primate sub-branch, which includes monkeys, apes and others like lemurs, tarsiers and lorises. The first primates appeared about 70 million years ago. About 20 million years ago, out of Africa came the Oak Ape, *Dryopithecus*, the ancestor of all the modern apes, including the chimpanzees, gorillas, orang-utans and humans.

You Don't you mean the apes and the humans?

Me No, I think it is pure conceit to give us a group by ourselves. I'd rather make the continuity more explicit by including humans among the other apes.[1]

Our closest relatives here are the chimpanzees, which is probably why they are so appealing to us. In fact, our genetic makeup differs from that of the chimps by only 1%. It is an important 1%, but it is nonetheless clear that in terms of our physical makeup we are just a variation on the ape theme. Chimps are highly intelligent animals. They can do simple counting and fractions, and can recognise simple geometrical shapes. Someone has estimated that chimps have an IQ (in human terms) of 80[2], which is not bad at all.

There have been many experiments in which people have tried to teach chimps human language, with a certain amount of success. Chimps do not have the muscular control of their faces and vocal chords needed to

produce words, but they can learn to use sign language, or to communicate using special keyboards and they can understand limited human speech. They tend to combine words with gestures. The Bonobo chimps seem to have the most advanced abilities. They can understand sentences of the complexity of:

"Get a Coke and give it to Rose. The Coke is on the table there."

"Get the ball that's outdoors." (another one was in view)

Their language ability is limited to objects and events in their direct experience, and is comparable to that of a child of two or so.

Chimps are very social animals with active and intricate social lives. They live in bands for mutual protection and companionship, spending much time grooming each other. They can spontaneously learn to use

objects around them as simple tools. They use twigs to fish ants from holes in wood. Groups of chimps hunt monkeys: some will chase the monkey into an ambush formed by several others. Fighting is common among chimps, but their social bonds are so important to them that fights usually end in reconciliation.. "Within a minute of a fight having ended the two former opponents may rush towards each other, kiss and embrace long and fervently and then proceed to groom each other."[3]

There is a dominance hierarchy of males and females in a chimp band. The most dominant male has the greatest sexual access to the females when they are in heat. His function is to protect them from attack or annoyance, especially by other males. To maintain his dominance he needs the active assistance of the females. In *Chimpanzee Politics*, Frans de Waal describes the intricate manoeuvres chimps get up to as one male, or perhaps a pair, will challenge another for dominance. "Whole passages of Machiavelli seem to be directly applicable to chimpanzee behaviour".[4] Deception is part of their normal repertoire of behaviour. This is significant in what it tells us about chimpanzee mental abilities: for a chimp to be able to deceive another, it must be able to imagine what it is like to be that other chimp.

Chimps have friendships, but do not form permanent sexual bonds. Female chimps do not normally mate except when they are in heat. When a female chimp is in heat, the other males pay special attention to her, and may bring her gifts of food. Otherwise, food is not generally given by one chimp to another, although a group will share eating an animal they have killed.

Humans and chimps parted company around four million years ago. The climate had changed somewhat; the forests were shrinking, but there were opportunities for apes to exploit on the edges of the forest. Perhaps it helped if you could run out of the forest into a nearby clump of vegetation,

grab some fruit or nuts and carry them back to the safety of the forest. To do this you had to use your hands and walk on your feet only. (Apes can walk on their legs and carry things with their hands if they want to, but normally they walk on all fours, putting some of their weight on their knuckles. Like most mammals, their backs are suited to supporting their body's weight at both ends.)

The apes that exploited this new way of living soon became adapted to it. The angle of their hips changed, their feet changed, the angle of their heads changed. Their backs – bone and muscle – adapted to standing on one end to support the entire weight of their bodies. These upright apes, *Australopithecus*, were our earliest direct ancestors. Other than their upright stance, they were like other apes. Their brain size was the same, and we can presume that they were as intelligent and social as the other apes.

There is another way in which humans differ from the other apes, one mentioned less often than our big brains and upright stance. We are by far the sexiest of the apes. Our women are sexually receptive even when they cannot conceive; they have lost the ape's distinguishing physical signs of being on heat. Women have sex when they are pregnant, during menstruation, and on into old age beyond the childbearing years. This increased sexuality probably dates from very early in human evolution, at the time of *Australopithecus*. For us, sex has taken on an additional function. It is not just to conceive children: it also promotes bonding between people, a first step towards increased sociability and culture.[5]

Standing upright might have had its advantages for food gathering, but it also created certain problems. The change in the angle of the pelvis disrupted the easy passage of the infant through the birth canal. The difficulty humans have in giving birth started at this early point, and was compounded much later when human brain sizes increased. The solution

was that babies were born slightly earlier, and thus smaller, than other ape babies. These less mature babies needed more care than earlier ape babies, so the friendly attention of the men was very welcome. The food sharing which was offered to a sexually receptive female previously would be of great benefit to a sexually receptive female with an infant. Any increased care and attention would promote the survival of mother and child. Thus was born what Helen Fisher calls 'the sex contract', a close tie between two people for mutual support based on sexual attraction, but not just to produce babies. It developed into our present sexiness and contributed to what we call falling in love.

Standing upright itself, with the new angle of the pelvis, might have promoted increased sexuality as the sexual organs were displayed more directly. Eye contact was enhanced and face-to-face sex, with its greater intimacy, became more favoured. Various physical differences between humans and the other apes are likely to have arisen at this time and would have increased human sexiness – loss of most body hair, skin that is more sensitive to touch, enlarged breasts (as a reminder of the sensuality of nursing?), larger penises, and prolonged sex. (For chimps it lasts just 15 seconds.)

From this early stage, becoming more like what we would call human was to do with increased sociability. The early bonds between men and women were a step towards human culture: one could even speculate that face-to-face sex, close eye contact and more kissing meant that the muscles of the face and mouth became more flexible, allowing subtler movements. As the couple had more to do with each other, communication between them would become much more important.

You So it was the *Australopithecus* women who first started saying to their men, "We need to communicate more!"

Me Probably yes! My speculation is that the physical changes for increased sexiness pre-adapted people for better communication and speech.

Mary Leakey discovered a famous set of fossilised footprints of a small group of *Australopithicus* in Tanzania. As Helen Fisher interprets it:

> "The time was the beginning of the wet season some 3.6 million years ago... On this afternoon a large adult hominid, about four feet eight inches tall, was strolling through the damp volcanic ash. Beside him was his companion, a smaller (probably female) hominid about four feet tall. They strode through the muck together, almost rubbing shoulders. Behind the larger individual, another smaller one followed, carefully stepping in the footsteps of the leader. …Mary Leakey thinks that the two adults who walked side by side almost four million years ago were holding hands; that all three were playing."[6]

So now we have an upright ape, with hands free to carry, manipulate, and use tools, and with an increased sexuality to promote bonds between individuals. These bonds created collaborations that would have been to the benefit of the individuals and the whole band: more efficient gathering of food, protection and child care.

Me As I've stuck my neck out this far, I might as well stick it out still further.

With this heightened sexuality, no longer linked only to procreation, and with the advantages that sexual bonds brought, sexual bonds may have developed between two men or two women. These, too, would have been beneficial to survival. Two men might become a more efficient hunting

team. Two women might share the care of children conceived with their male lovers. As no offspring are produced, homosexual bonds would have been relatively infrequent, as they are now. Nonetheless, it is consistent with this pattern to see homosexuality appearing very early. It seems to be a small part of the normal human sexual repertoire, just as red hair is a small part of the normal variation of human hair colourings.

Towards modern humans

Australopithecus may have been an upright-walking, sexy, social ape, but was still a long way from the big-brained, talking, cultured people of today. The next major change occurred about 1.6 million years ago, probably triggered again by climate change. The Earth entered another phase of ice ages which continues today, so far as we know. Because these ice ages are so much more recent than the ice ages 2.5 billion and 570 million years ago, there is much more evidence.

You Another period of ice ages? I don't understand. If the Earth cools down so that conditions are right for an ice age why does it heat up again so the ice ages end only to be followed by another period of ice ages much later?

Me The best sense I can make of it is that over the longest time scales, billions of years, the Sun is getting hotter, and so if it weren't for life, the Earth would now be very much hotter than it was in the early Archaen age. In fact, it might now have been much too hot for life as we know it. However, life has gradually been reducing the carbon dioxide in the atmosphere, so keeping the temperature more or less the same. At times it gets a little cooler and the Earth slips into

ice ages. The difference in average temperature between ice age and no ice age is only a few degrees.

A few million years ago, a new type of plant evolved which could live more efficiently on lower levels of carbon dioxide, and carbon dioxide levels fell still lower. Various other conditions were significant too: the continents had shifted to suitable positions, with Antarctica over the South Pole where it could support an ice cap, and a ring of land around the North Pole on which an ice cap could form. The result was that the climate became unstable and could easily be triggered into or out of an ice age about 1.6 million years ago. Since then the Earth has oscillated into and out of ice ages regularly – triggered partly by wobbles in the Earth's orbit.

Between 1.6 million and about 730,000 years ago there have been about 20 short cycles, lasting about 40,000 years each, of ice ages followed by inter-glacial periods. In the past 730,000 years there have been about eight more cycles, with the earlier cycles lasting about 70,000 years and the later ones about 100,000 years. We are presently in an inter-glacial period that began roughly 10,000 years ago. The one before was about 130,000-115,000 years ago.

The next stage on from *Australopithecus* – with much larger brains – started to appear at the beginning of this ice age period, 1.6 million years ago. But it wasn't until the beginning of the last interglacial, 130,000 years ago, that fully modern people appeared with bodies more or less the same as ours. So most of the time since big-brained humans appeared, the Earth has been in an ice age.

The dramatically changing climate of the past 1.6 million years created crisis after crisis to which all life on Earth, including developing humanity, had to adapt. During the inter-glacial periods, huge parts of the land were covered in forest – temperate in cooler areas and rainforest in the tropics.

During the ice ages, ice sheets covered large parts of Europe, Asia and North America. Below this was largely tundra. The rainforests shrank and fragmented into small, separate areas. When the next inter-glacial arrived the forests and rainforests rapidly re-grew and joined. This repeated fragmentation and re-joining is probably responsible for the enormous variety of species found in rainforests, which are now fragmented by us. Crisis after crisis also favoured the evolution of more generalist animals, like humans.

Like chimpanzees and gorillas, *Australopithecus* had a brain size of about 450cc. The earliest of our bigger brained ancestors, *Homo habilis*, had a brain twice that size (and we have brains about three times that size.). Their hands were almost as dextrous as ours. With their remains have been found simple stone tools, probably used for crushing nuts, breaking open bones to expose the marrow, other food preparation, scraping, cutting and hammering. They did only a little shaping of the natural stone, choosing stones with a useful shape to start with.

Later, and somewhat bigger-brained, *Homo erectus* first appeared in Africa about 1.6 million years ago. By 730,000 years ago they had spread to the Middle East and southern Europe. By 250,000 years ago they had spread throughout Europe and Asia.

They used quite a variety of stone tools, carefully shaped. They made hand axes, choppers, chisels, scrapers, cleavers, awls, anvils and hammerstones. To do this they had developed quite elaborate techniques for breaking and shaping stones. They also built dwellings and used fire. With this level of sophistication, they were likely to have used animal bladders to carry water and use animal skins for clothing in the cold ice age winters.

This is a long way from the lifestyle of the oak ape, ancestor to all the apes. This is culture: people learning detailed ways of doing things from

each other. It wasn't only the bodies (including brains) of our ancestors that were evolving, their ideas were evolving too. The technologies of making tools and the lifestyles associated with them were passed from person to person and from generation to generation. For these early humans the intricate web of life in which all creatures are enmeshed now included their ancestors. Human culture – relationships with other humans – came to be more and more important as part of the environment of an individual human.

The evolution of bigger brains and early human cultures were two aspects of the same process. Bigger brains allowed the understanding needed for the developing culture, which in turn created the pressure for the elaboration of the brain.

Part of this process must have been the development of language. Early language would have been very close to direct experience and memory, a few steps beyond what a chimpanzee can learn today. It was a language of objects, and manipulating objects, simple stories of how to do this, and what happens when you do that. What can you eat and how do you prepare it? Where and when are these plants found? How do you catch and kill these animals? This made a major difference in the life experience of early people. Along with their direct experiences of food, other creatures and the weather, they had experiences shaped by language. There were associations between certain stones and the tools they could make, names that linked whole classes of objects. Thinking, as we know it, was born.

Modern humans

Homo sapiens seems to have evolved in Africa too, descended from *Homo erectus* populations there. They first appeared around 130,000 years ago, and they too spread widely. They had arrived in the Middle East about

90,000 years ago, had spread throughout Europe and even reached Australia by 40,000 years ago, but did not get to Japan or Siberia until about 30,000 years ago. They reached North America some 10-15,000 years ago. In the middle of the ice age, with so much water locked up in the ice sheets, the sea level was much lower. There were land bridges between Siberia and Alaska, and only a short distance by sea to Australia.

By about 60,000-40,000 years ago, in the middle of the last ice age, came fully modern humans, *Homo sapiens sapiens*. At around this time a new level of culture appears in human remains. This was the time of cave paintings of animals and people, which appear beautiful even by modern artistic standards. Tools with great aesthetic appeal appear. This was a time of ritual burial – bodies carefully laid out with a variety of objects. Beautiful carved statues have been found, in the form of abstractions of a pregnant woman. These are generally interpreted as symbols of a fertility goddess. Abstract thought, symbolism and religion had arrived. This is quite recent on the time scale of human evolution. There appears to have been very little further development of human bodies and brains since. If an infant from that time were raised in a modern western city, it would probably be indistinguishable from the rest of its new family. Its speech would be fully fluent and with a modern accent. It might grow up to be a nuclear physicist or a politician.

You More likely unemployed. You say a politician, but didn't you also say that chimpanzees were good politicians?

Me I said that chimpanzees' social manipulations were Machiavellian, but they are not capable of giving a speech showing that their actions are for the public good!

The point is that the level of complexity of human culture that had evolved

by the time *Homo sapiens sapiens* appeared was fully modern. Brains capable of handling the level of abstraction their cultures required are also capable of handling the abstractions of modern science. Languages subtle enough for their purposes were subtle enough for the careful shadings of truth of modern politicians. What continued to evolve were the ideas, technologies and forms of social organisation.

The early *Homo sapiens sapiens* lived in small bands, of perhaps 30 to 50 people. They were wandering gatherers and hunters. This has been the principal way of life of humans from the very beginning. It began to be displaced with the beginnings of agriculture about 10,000 years ago, and then still more with the advent of cities and large scale social organisation, about 5,000 years ago. Substantial populations lived in this way as late as the 19th century, but only small isolated pockets of these cultures are left today.

The gathering/hunting way of life required a very detailed and sophisticated understanding of the life cycles of plants and animals. Which parts are good to eat? Which have medicinal properties or can be used as poisons to hunt others? How do you make tools for carrying, hunting or shelter out of stone, bone, wood, or animal parts? Where are the game animals or the ripe edible plants this week?

All of this was wrapped in a rich social life in which people collaborated in finding and preparing food, and caring for their children and their old people. Talk around the campfires might be of the availability of food, but also gossip about the doings and mis-doings of the people in their own and neighbouring bands. Our complex brains and languages evolved with and were formed by the need to cope with this rich knowledge of the natural and social environment. Most adults knew most of what was needed to thrive. By contrast, in modern cultures the cumulative and stored knowledge is much greater, but any individual knows very little of that total.

A major function of culture has always been the maintenance of the bonds between people, because interactions with other people make up a very large part of the environment in which people live. Many cultural devices evolved to support this: rituals, music, dance and ceremonies.

You Let me get this clear: are you saying that the purpose of music and dance is to maintain bonds between people?

Me Yes, I imagine that they evolved fairly soon after abstract thought evolved, and for exactly that reason. Any aspect of developing culture that supported group coherence would aid group survival and would be likely to continue. That is also why music and dance have such a strong emotional impact.

The development of abstract thought meant that human minds could add extra layers of association to their experience. Not only could they distinguish tigers but could recognise that many different animals had the same cat-like qualities. They could even associate aspects of cat-like behaviour with aspects of human behaviour. This is metaphor, the mapping of the qualities of one set of experiences onto another. With this ability to use metaphor, many mysterious patterns which people experienced could be explained in terms of familiar social experiences. So the essential nature of the deer might have been given a separate existence, with human-like qualities: a deer-spirit. If there were few deer around to hunt perhaps this deer-spirit had been offended. This is animism, the explanation of natural patterns in terms of spirits or souls.

Early modern humans would have had a very clear intuitive sense of the picture painted in the last chapter – of the inter-connectedness of all living creatures, of the inherently supportive quality of nature, and also of almost constant chaotic and disruptive change. They would have expressed

it in the only vocabulary and images they had available: metaphors expressing natural patterns as human-like spirits. They were clear about their part in this interconnectedness, and treated nature with respect.

> "…for hunter-gatherers themselves, a central concern has been their relationship with the creatures they harvest. In this form of management, people trust that if they do the right things, the world will stay as it should; the creatures and plants they eat will feel welcome and know they are respected, and will therefore continue to make themselves available."[7]

This respect generally applied to other people as well, and reflected the nature of gather-hunter social organisation.

> "The egalitarian individualism of hunter-gatherer societies, arguably their greatest achievement and their most compelling lesson for other peoples, relies on many kinds of respect."[8]

This was the time of the goddess cultures. Lovely statues and images of a pregnant woman, somewhat abstracted with no details of face or hands, are found associated with many ancient cultures. They are likely to have symbolised nature, what the ancient Greeks called Gaia, the Earth goddess.

You You seem to be romanticising these cultures. Weren't these also woman-bashing cavemen? Do you really imagine a nature-worshipping, peace-loving, hippy paradise?

Me No, I'm simply trying to counter the view that before civilisations started, humans were ignorant, aggressive savages, struggling against the odds for survival. That is why I am emphasising the collaboration, intelligence and intuitive wisdom of early cultures. But I haven't finished with the issue of aggression.

It seems clear that one side of being human is an animal that has taken sociability and collaboration far beyond that of any other animal. We are adapted to it physically, with the language abilities of our brains, faces and vocal chords. With our extended sexuality, and our generalised ability to feel love, we are adapted to it emotionally. Another side of being human is an animal that has taken aggression and conflict far beyond that of any other. These two sides clearly both co-exist in modern cultures. The question is whether the extremes of aggression and conflict exist in all human cultures? Are they – like music, dance, language and our sexiness – a mark of being human or do they only apear under certain conditions?

They do seem to be universal in so-called civilised cultures. And since civilised cultures are a boundary beyond which people rarely look when considering human nature, the myth that they are universal has flourished. To set this straight it is worth considering the range of human cultures that has existed since the appearance of *Homo sopiens sapiens*, some 40-60,000 years ago. From the artifacts left by a prehistoric culture it is very difficult to determining how agressive the people were. Speculations about this probably say more about the preconceptions of the investigator than of the culture. It is better to consider studies of similar cultures which have existed recently. Some certainly are fierce and warlike, others gentle and peaceful. Here are some examples of the latter.

The people of Tahiti

"The people in general are of the common size of Europeans... their gait easy and genteel and their countenance free, open and lively, never sullied by a sullen or suspicious look — their motions are vigorous, active and graceful and their behaviour to strangers is such as declare at first sight their humane disposition, which is as candid as their countenances seem to

indicate, and their courteous, affable and friendly behaviour to each other shows that they have no tincture of barbarity, cruelty, suspicion or revenge. They are ever of an even unruffled temper, so they ought not to be suspected, and an hour's acquaintance is sufficient to repose an entire confidence in them."[9]

"Tahiti in the early 1960's when I began my field work there seemed in regard to gentleness little different than the reports of the late 18th and early 19th century had suggested. ...my own observations during a period of more than two years...indicated in comparison with Western experience and in comparison with reports of many other non-Western societies an extreme lack of angry, hostile, destructive behaviour."[10]

The Yequana of Venezuela

"[There] is a respect for each individual as his own proprietor. ...Deciding what another person should do, no matter what his age, is outside the Yequana vocabulary of behaviours. There is great interest in what everyone does, but no impulse to influence — let alone coerce anyone. A child's will is his motive force. ...The Yequana do not feel that a child's inferior physical strength and dependence upon them imply that they should treat him or her with less respect than an adult. No orders are given a child which run counter to his own inclinations as to how to play, how much to eat, when to sleep, and so on. But where his help is required, he is expected to comply instantly. Commands like 'Bring some water!', 'Chop some wood!', 'Hand me that!', or 'Give the baby a banana!' are given on the same assumption of innate sociality, in the firm knowledge that a child wants to be of service and to join in the work of his people. No one watches to see whether the child obeys — there is no doubt of his will to co-operate. As

the social animal he is, he does as he is expected without hesitation and to the very best of his ability."[11]

"One of the most striking differences between the Yequana and any other children I have seen is that they neither fight nor argue among themselves. There is no competitiveness and leadership is established on the initiative of the followers. In the years I spent with them, I never saw a child argue with another, much less fight. The only angry words I did hear were a very rare burst of impatience from an adult with a child who had done something undesirable."[12]

The Buddhist culture of Ladakh

"A concern not to offend or upset one another is deeply rooted in Ladakhi society; people avoid situations that might lead to friction or conflict. When someone transgresses this unwritten law, ...extreme tolerance is the response. And yet concern for community does not have the oppressive effect on the individual that one might have imagined.

In traditional Ladakh, agression of any sort is extremely rare: rare enough to say that it is virtually nonexistent. If you ask a Ladakhi to tell you about the last fight he can remember, you are likely to get mischievous answers like 'I'm always beating up my neighbor. Only yesterday I tied him to a tree and cut both his ears off.' Should you get a serious answer, you will be told that there has been no fighting in the village in living memory. Even arguments are rare.

I asked Sonam once, 'Don't you have arguments? We do in the West all the time.'

He thought for a minute. 'Not in the villages, no — well, very very seldom, anyway.'

'How do you manage it?' I asked.

He laughed. 'What a funny question. We just live with each other, that's all.'

'So what happens if two people disagree — say about the boundaries of their land?'

'They'll talk about it, of course, and discuss it. What would you expect them to do?'"[13]

The Fore of New Guinea

"The Fore protoagricultural communities were quite different from anything I had previously encountered. There were no chiefs, priests, medicine men, or the like. Moving about at will and being with whom they like, even the very young enjoyed a striking personal freedom.

Infants rarely cried, and they played confidently with knives, axes and fire. Older children typically enjoyed deferring to the interests and desires of the younger; sibling rivalry was virtually undetectable. A responsive 'sixth sense' seemed to attune the hamlet mates to each other's interests and needs. ...A spontaneous urge to share food, affection, work, trust and pleasure characterised the daily life. Aggression and conflict within communities was unusual and the subject of considerable comment when it occurred."[14]

You That is quite amazing. I find it hard to believe. These descriptions don't sound like people as I know them.

Me Yes indeed, it just shows how limited are most people's experience of the possibilities of human nature.

For these cultures, and many others in the anthropological literature, there is a natural, intuitive sociability and co-operation with coercion and aggression rare. The lesson of the starlings applies: they combine freedom and collaborative support. For these people, this is the obvious way people behave.

You But let me be clear. You are not saying that all cultures were like that before civilisation.

Me No. I've been describing the extreme peaceful end of a spectrum. It simply shows that that extreme is within the bounds of possibility of human nature. I'll take a first look at some of the reasons for the differences now. Unpicking those differences fully is one of the main theme of this book.

Two of the books quoted in this chapter express strong views about why some cultures are more aggressive than others. They point to child-rearing practices as a major factor. Ashley Montague says:

> "Years ago Margaret Mead was the first anthropologist to inquire into the origins of aggressiveness in non-literate societies. In her book, *Sex and Temperament in Three Primitive Societies*,[15] she pointed to the existence of a strong association between child-rearing practices and later personality development. The child who received a great deal of attention, whose every need was promptly met, as among the New Guinea Mountain Arapesh, became a gentle, co-operative, unaggressive adult. On the other hand, the child who received perfunctory, intermittent attention, as among the New Guinea Mundugomor, became a selfish, unco-operative, aggressive adult. Later research among nonliterate and civilised peoples has substantially confirmed this relationship, and so do the studies presented in this volume."[16]

Jean Liedloff, in *The Continuum Concept*,[17] and Ashley Montague, in another of his books, *Touching, The Human Significance of the Skin*,[18] are even more specific. Jean Liedloff writes at length about "the in-arms experience", in which an infant in many pre-industrial cultures is continually carried in its mother's arms and is allowed to feed on demand.

Ashley Montague describes this same practice as an "external gestation". He says it is important because human babies are born relatively immature compared to other apes. The sense of security and being cared for in the womb is continued in the early experience of the infant. This provides the foundation for their later views of what the world is like.

You So we are back to permissive parenting. It is not so easy and can result in spoiled children rather than non-aggressive children.

Me There is much more to it than that. And 'permissiveness' does not capture the essence of it. The 'child as boss' approach can be as harmful as the 'parent as boss' approach. The key issue is the way the infant learns to see its environment. Is it being supported or is it being opposed?

Both Jean Liedloff and Ashley Montague are clear that child rearing is not the whole story. Ways of caring for infants and children cannot be taken out of the context of the whole culture. There needs to be a consistency between the supportive nature of child-rearing practices and the rest of the culture. This is what Jean Liedloff means by the 'continuum concept'.

The original affluent society

A quick look at the nature of economic systems in hunter-gatherer societies helps put our own economic system in perspective. Later chapters demonstrate that it is not the obvious best choice for our future.

There is a common view that life for hunter-gathers was very hard. “Our textbooks compete to convey a sense of impending doom, leaving one to wonder not only how hunters managed to live, but whether, after all, this was living.”[19] For the most part, this is projection in order to justify the difficulties

of life in civilised cultures. After all, if so many people are poor now, and we have the benefits of agriculture and civilisation, things must have been much worse before that. The reality was quite different. Early humans were a highly successful species, spreading throughout the world and becoming the top predator wherever they went. If they managed to survive those years when conditions were very difficult, they must have survived quite easily in the normal, good years. This easy life is the view of very many people who have studied modern hunter-gatherer cultures, and inspired Mashall Sahlins to call it "the original affluent society".[20] He cites various studies:

> "The most obvious, immediate conclusion is that the people do not work hard. The average length of time per person per day put into the appropriation and preparation of food was four or five hours. Moreover, they do not work continuously."[21]

> "The Bushman figures imply that one man's labor in hunting and gathering will support four or five people. Taken at face value, Bushman food collecting is more efficient than French farming in the period up to World War II. … For each adult worker, this comes to about two and one-half days labor per week. …A 'day's work' was about six hours."[22]

> "Reports suggest a mean of three to five hours per adult worker per day in food production. Hunters keep bankers' hours…"[23]

These days we have institutionalised hunger on an unprecedented scale, quite unlike the Old Stone Age. The industrial and commercial working week we have come to expect is not what humans faced through most of their evolutionary history. Production of food and many of the other goods of everyday life is a co-operative venture in hunter-gather societies. People do things with and for each other, exchange and give gifts. Sometimes this is

casual and informal, sometimes highly organised, formal and even ritualised. The range of different forms of exchange is as varied as there are human cultures. Sometimes this exchange is local, within a family group, and other times it may be more distant, as trade. Here are a couple of examples.

The !Kung bushmen of the Kalahari Desert

Although they live in a desert, the bushmen consider their homeland abundant and beautiful. They hunt various animals and gather a wide range of plant food. Their staple is the mongongo nut, which is easy to gather, and highly nutritious. In discussions with anthropologists it is clear that they were capable of planting the nuts, if they chose to do so. But one commented: "Why should we plant when there are so many mongongo nuts in the world?"[24]

Hunting is more difficult and less reliable than gathering. When a hunter kills an animal, it is his responsibility to divide it up among the members of the band. This is a socially complex act, guided by relationships, past giving, and precedent. Often a young man will seek the advice of his elders on it to ensure he does not commit a *faux pas*. In contrast, gathering of plant food is easy and is done by everyone. The food gathered is shared widely and casually.

The Trobriand Islanders and the Kula ring[25]

For more settled groups, with simple agriculture, exchange is often more complex. The Trobriand Islands lie to the east of New Guinea. Much of the food of the islanders comes from shifting gardens, planted in different places in different years. There is a complex arrangement of ownership and use of these gardens. The *Towosi* (garden magician) supervises the clearing, planting and tending of the gardens. He initiates each stage of the

gardening with a magical rite, which determines its timing. His expertise, expressed through the rituals he runs, thus ensures that everyone gets the best out of the land. Community members give ritual gifts to the *Towosi* as part of the ceremonies.

"There are different systems of communal work on various scales; sometimes the several village communities join together, sometimes the whole community, sometimes a few households. …In the more extensive kinds of work it is the chief's duty to feed the workers."[26] There is a lot of redistribution of garden produce according to custom and ritual. This is a culture that is "enmeshed in a network of reciprocal obligations and dues, one constant flow of gift and counter-gift."

The chief is given ritual gifts of food on various occasions. He acts as a storehouse and redistributor. He can also transform food into objects of permanent wealth, through trade with other communities.

There was a trading system, called the Kula Ring, that included not just the Trobriand Islanders, but many other island communities to the east of New Guinea.[27] It was based on the exchange of two types of article of high value but of no real use – armshells and necklaces made of red shell-disks. Both were intended as ornaments but hardly used even for that purpose. Neither was kept for very long. Both travelled on a circular route, through trading partners with life-long relationships. An old chief might have a hundred trading partners, while a young commoner would have only a few. The necklaces travelled clockwise while the armshells travelled counter-clockwise along the trading routes. Thus in each trading pair one person would be giving the other armshells and receiving necklaces, while the other would give and receive the opposite.

The armshells and necklaces were in very limited supply. There was only a loose sense of the equivalence of the various valuables. The more

valuable of them had individual names and histories and were known far and wide. The objective of the trade was to arrange to obtain the more prestigious ones from your trading partners. You in turn would soon pass them on to one of your other partners, thus obligating them to give you something prestigious in the future. To sweeten the trade, and to entice your partner to give the best objects to you, rather than to one of his other partners, all sorts of gifts were given as well. This included much more practical and useful items, such as pigs, yams and various other things. The trade enabled islands with agricultural surpluses to supply islands with less food, but other useful objects.

This trade had very great practical benefits to the people that participated in it. However, from their point of view, it was the prestige of receiving high value Kula items that mattered socially, not the practical uses of the side gifts. There is a similarity here with our modern economy. In both cases, the medium of exchange (money for us, armshells and necklaces in the Kula ring) takes on primary importance and appears to be the purpose of the trade.

The reciprocity spectrum

Sahlins classifies these forms of exchange along a spectrum, from what he calls generalised reciprocity, through balanced reciprocity, to negative reciprocity.[28]

- *'Generalised reciprocity'* includes the most altruistic forms – gifts, sharing, hospitality. However, generalised reciprocity is not simply a one-way transfer. There is an expectation of a return, but not on an immediate basis, or for a given item. So parents look after children who they expect to look after them when they are older. Such practices as 'kinship dues', 'chiefly dues' and 'noblesse oblige' are also examples of generalised reciprocity. Generalised reciprocity implies an on-going

relationship between the people concerned. They are part of the same family, band or tribe.

- *'Balanced reciprocity'* is the mid-point of the spectrum. The return is immediate. This is the classic form of barter and includes much of what involves 'primitive money'. It is less personal than generalised reciprocity, and involves a looser relationship.

- *'Negative reciprocity'* is "the unsociable extreme, …the attempt to get something for nothing with impunity. …The participants confront each other as opposed interests, each looking to maximise utility at the other's expense."[29] The extreme end of negative reciprocity is theft, rape and pillage.

For the !Kung bushmen, and most hunter-gather societies, exchange tends to be at the generalised end of the spectrum. In the Trobriand Islands, exchange within a community was more generalised while the Kula ring tended more towards balance. In our modern economy, exchange tends to range between the balanced and negative ends of the spectrum. The eGaian image is of exchange that retains the complexity and richness of the technological world, but with the use of communication technology to support new social forms that allow a return to the generalised end of the spectrum.

CHAPTER six

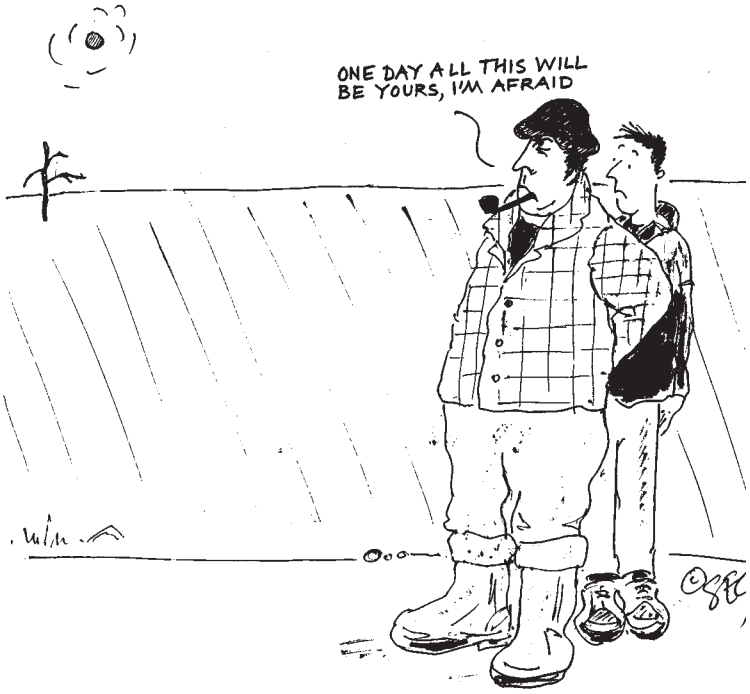
Towards the global cancer: the late human story

The origins and early history of humanity is about the ape that specialised in co-operative behaviour, developing language and culture as a means of enhancing our survival. Early humans lived a life to which they had evolved and adapted over nearly two million years. Their impact upon the natural world was comparable to that of other medium-sized mammals. Then, over a time period which is an evolutionary blink of an eye, humanity came to dominate the world, to have an impact which can be seen as a global cancer. This chapter traces that stage-by-stage transition. Recent research into the mechanisms of cancer shows that it too starts gradually:

> "Cancer begins deep inside the molecular machinery of a cell: first one genetic mutation, then another, and so on until the gene products that provide the usual checks and balances to cell division go awry, and the cell careers down the path of uncontrolled, cancerous proliferation."[1]

The course of humanity's global cancer shows a similar progressive loss of connection from the natural world and the checks and balances of evolution.

- With the development of settled living and agriculture, humanity started to become disconnected from the natural constraints on obtaining food, so its population could begin to rise.
- With the beginnings of civilisation and with it the transition from oral cultures to writing, human thought and spiritual life began to lose its intimate connection with natural processes. Wars, conflict and environmental destruction took a great spurt forward.
- With industrialisation came the change from wood and wind for



energy to the use first of coal and later oil, gas and finally nuclear fuels. The natural constraints upon energy use began to be lost. The impacts of human technology could increase until they were large enough to change the climate.

- The final stage was reached in the late 20th century with the development of a globalised, commercially-dominated world economy. The constraints of local cultures were lost, and to a large extent those of national governments. Unending growth of production became the shrine and goal of public policy, with the preservation of the Earth an unpleasant side-issue that has to be coped with somehow.

Fortunately the possibility of a global eGaian culture was also established in that final stage. For the first time, there is the possibility of a new stage in evolution: self-awareness and co-ordination on a planetary scale.

You Hang on. Don't get carried away. And your potted history of human culture sounds a bit simplistic.

Me I'm sure it is hugely oversimplified. But let me spell the four stages out in a bit more detail.

Disconnection from food: settled agriculture

This final chapter of the human story starts about 10,000 years ago, at the end of the last ice age. At the time, the total human population of the world was about 4 million. Then, for reasons that are not very clear, people began to lead more settled lives. They began to replace hunting with the domestication of animals and to replace gathering with crops they planted.

At one time it was thought "that the advantages of agriculture were so obvious that it must have been adopted as soon as human genius and invention had progressed far enough. Now such easy answers seem less

plausible."[2] The hunter-gather life seems generally to have been easier. There was no need to plant, harvest and store crops. Agriculture relies on fewer crops so that in a bad year shortages and famine are more likely. Wilkinson speculates that rising populations led to a loss of 'ecological equilibrium'.[3] Perhaps the rising population was an over-reaction to the warmer, lusher conditions that appeared when the ice age ended. So here again, it may have been the response to a crisis that led to a breakthrough.

Agriculture seems to have developed independently in different parts of the world using different crops and animals. "The key centres were south-west Asia, China, Mesoamerica, the Andes and the tropical areas of Africa and south-east Asia."[4] Within these past 10,000 years it has spread throughout the world. Now very few hunter-gatherer societies remain, mostly in very isolated areas, usually with extremely small populations.

Whatever the reasons for its origins, once it became more highly developed, agriculture began to produce food surpluses. This meant that human populations could increase beyond the limitations of the carrying capacity of the land for gatherer-hunter societies. Humans had made a major break from the natural constraints on population for animals in the wild. The parallels with a cancer are clear.

The change from gatherer-hunter cultures to agriculture was a major one in physical ways for our co-operative ape. The diet and way of life that had shaped human physiology and psychology had changed substantially. The flesh of wild animals and fish is much less fatty than that of domesticated animals. Dairy products and grains as staples were new additions to the human diet. Not surprisingly, even today they are harder for us to digest than fruit and vegetables. For example, it is thought that for a person to retain the ability to digest milk after they are weaned is an adaptation that evolved in early cattle herders.[5] Most of humanity,

especially in southern Europe, Asia and Africa become intolerant to lactose after weaning.

> "Studies of today's few remaining traditional hunter-gather communities reveal a virtual absence of raised blood pressure, obesity, heart disease and diabetes in middle and late adulthood. This mismatch between our Pleistocene-attuned biology and our current way of life has been amplified over the past century as urban sedentariness, dietary excesses and various socialised addictive behaviours (alcohol consumption and tobacco smoking) have become prominent features of modern human ecology."[6]

Disconnection in thought and spirit: civilisation

Early human cultures had a sense of connection with the natural world around them which is not at all part of the life experience of most people today. That disconnection took a great leap forward with the transition from settled farming to civilisations. In many cases those early farming societies also became more hierarchical and unequal. Ponting takes up the story:

> "Chiefs and religious authorities controlled much of the surplus food and redistributed it mainly in accordance with their priorities. As they did so they exercised more control over the people in their community. …Societies at this level of development existed everywhere across the world for thousands of years…"

> "In a handful of areas some societies… went much further and became coercive states and created the organisations, institutions and culture which we call civilisation. This process occurred at most six times in human history – in Mesopotamia, the Indus valley, China, Mesoamerica and the central Andes."

> "These societies were distinguished by a number of features – they supported an elite of thousands of non-producers (priests, rulers, bureaucrats, craftsmen and warriors) who lived mainly in cities and who exercised power over the rest of the population through forms of taxation and tribute. …Most developed some form of written script for various forms of record keeping."[7]
>
> "The evolution of writing was central to the development of civilisation…it was fundamental to the functioning of the state in most early civilisations. Its purpose was not to represent a language but to store and transmit information. At first this was mainly about trade and administration…"
>
> "Writing was central to the power of the state and the ability of it and the elite to control and exploit the majority of people."[8]

It was in these newly invented states, with their controlling elites, that the disconnection of thought and spirit began. David Abram, in *The Spell of the Sensuous*[9], presents a persuasive picture of its origins. His thesis is that the change from oral cultures to cultures with writing (and especially alphabetic writing) was the key point of change.

Oral cultures perpetuate themselves through continually telling stories about their surroundings. Stories about specific locations and about plants and animals are crucial to their understanding of how to live. 'Spirits', as we call them, were not abstract, disembodied essences, in some other non-material realm, but aspects of the natural world around them. In their use of language, oral cultures participate in the world. "Here words do not speak *about* the world; rather they speak *to* the world, and to the expressive presences that, with us, inhabit the world." This is in contrast to "the character of linguistic discourse in the 'developed' or 'civilised' world,

where language functions largely to deny reciprocity with nature–by defining the rest of nature as inert, mechanical, and determinate…"[10].

As writing progressed beyond record keeping to literature and philosophy, particularly in ancient Greece, this disconnection intensified. Oral culture, with its constantly repeated stories preserving cultural wisdom, became less and less important. People could look back at the written word, reflect on it and comment on it. This became the dominant way in which the culture was passed on. The evolution of human cultures had taken on a life of its own, no longer intimately tied to direct experience of the natural world.

People live in an environment shaped at least as much by ideas as by their direct experiences. These collections of ideas can regenerate and maintain themselves as they are passed from person to person. Once freed from the constraining bonds of nature, it was perhaps inevitable that all the features of the global cancer would eventually appear.

The practicalities of living in the early cities created a major disconnection from the natural world. Those who were not directly engaged with producing food were much less connected to it. Those who were, found that their activities and demands were increasingly determined by their relationships with the others who controlled them. People began to rely on other people to provide much of what they needed. It was no longer the case that most people knew most of what there was to know in the culture. Most still worked on the land, but others specialised in producing implements, cloth, or in building or trade. This meant that people were no longer dealing directly with people they knew well.

Trade and barter became more important and money appeared. Money in the form of coins was said by Herodotus to have been first used in the 8th century BC. "They are the first people on record who coined gold and

silver into money, and traded in retail."[11] The close coupling of producer and consumer had begun to loosen. Exchange had begun to move farther from the generalised end of Sahlins' reciprocity spectrum.

The sense of intimate support in the gathering-hunting band was no longer there. The earliest reports of widespread crime, corruption and dissolute youth come from the early civilisations. Professional fighters and standing armies appeared. Now there were groups of men whose principal function was to enforce the will of some groups on others. Wars on a much larger scale appeared. The technology of war took a huge leap forward in weaponry, military tactics and training. There were wars between gathering-hunting groups too, but they were conducted by men whose usual role in the culture was hunting and gathering. Those earlier wars were often highly ritualised, like much animal conflict. A war might end when the first blood was spilled.

Environmental problems appeared. Fertile land was farmed too intensively in places, creating deserts. Parts of northern Africa, now desert, were the granaries of the Roman Empire.

With all the social and political change came a new set of mythologies and world views. Authoritarian male gods and hierarchies of gods appeared, reflecting and justifying the political hierarchies in the early civilisations. The Earth mother goddess (the original incarnations of Gaia) and all the spirits of natural forces had lost their central place.

You So our global cancer really started with the beginning of civilisation? Are you saying it would it be better for the Earth if we all returned to that early hunter-gatherer lifestyle?

Me The size of the human population is far too great for the Earth to support us as gatherer-hunters. It is now about 1,500

> times as large as it was at the end of the ice age, one measure of the extent of humanity as a global cancer. Moreover, I don't think it is remotely desirable from humanity's perspective. What I do think is possible is that we could regain the social intimacy and supportiveness of the most peaceful gatherer-hunter cultures while retaining a sophisticated technology, perhaps something like I described in the Pinecone Network story.

Disconnected energy and technology: industrialisation

The start of industrialisation in the 18th century marked another substantial increase in the impact of the global cancer, and of the disconnection between human cultures and the environment. The key to this increased impact was the development of new energy sources that enabled a huge growth and development of technology. In the 1750s agriculture occupied about 90% of the population. The relatively low productivity of agriculture limited the population overall and the proportion of the population that could be supported outside of agriculture. By the end of the 20th century, less than 5% of the population of the industrialised countries worked in agriculture.

The principal source of energy for agriculture up to the 18th century was human labour. Animals were used too, but humans ate less food. Supporting a horse required 4 or 5 acres of land. Oxen needed slightly less and so were the main draught animals. In 18th-century Europe there were about 24 million oxen and about 12 million horses.

> "As late as 1806 one French agricultural writer could still advocate abandoning the plough and returning to digging fields by hand which although slower, was cheaper and more thorough."[12]

According to Ponting, industrialisation started first in England, not because it had increased its agricultural productivity but because it was able to import large quantities of food from its nearest colony – Ireland.[13] This, combined with the forcible eviction of peasants from their land by the big landlords, provided a workforce for the new industrial economy. Once started, the expansion of income from trade and increased imports from the colonies created a spiral of growth.

Waterpower was the main energy source for much early industry, with textile industries and other factories strung out along suitable rivers. In areas like the Netherlands, where waterpower was limited, wind was exploited. Wood was the main fuel until the 19th century. In the form of charcoal it was the primary industrial fuel for iron smelting, brewing, and glass making. It took a lot of woodland to fuel the early industrial revolution. An average small iron furnace used up about 250 acres of woodland every year. So industrial output was limited by the availability of what we now call renewable energy sources: human and animal power plus water, wind and wood.

Wood was also used for things like the construction of buildings, ships or furniture – so intensively that it became scarce. People had to make do with coal, considered a much inferior fuel at the time because it had to be mined and because it smelled bad when it burned.

> "There is so great a scarcity of wood throughout the whole kingdom… the inhabitants in general are constrained to make their fires of sea-coal or pit-coal, even in the chambers of honourable personages."[14]

Once again, a change was adopted not because it was seen as an advance but because of a crisis in the older system. Once adopted, the new fuel opened new horizons. The growth of human industry was no longer

constrained by the available energy from renewable sources. All of those were obtained indirectly from current sunlight falling on the Earth. Now energy was obtained from ancient sunlight, from forests that grew about 300 million years ago. This was the beginning of human ability to pollute the Earth on a grand scale. As coal was followed by oil and then gas as major fuels, more and more ancient forests were burned. Ancient carbon that had been removed from the atmosphere was returned as carbon dioxide. This was the beginning of global warming. The global cancer was getting large enough to change the Earth's climate.

In the early stages of industrialisation, the pollution from released carbon dioxide was insignificant compared to the more obvious pollution of the newly expanded industry.

> "By the nineteenth century across Europe and North America there were areas of concentrated pollution and environmental degradation – ruined landscapes of chimneys belching smoke and poisonous gases, huge slag heaps of waste materials, rivers full of a cocktail of industrial wastes and surrounding areas where the vegetation was destroyed."[15]

There were many other changes as well. The modern world was taking shape. Cities became much more important, What had been trading centres and a focus for the rich and their courts were now centres of industrial production.. Transport and communications improved, first with the development of canals and then, once the steam engine arrived, the railways. Governments took on new functions. Before that their main function was military. Now, with the new urban cultures, with a new class of industrial poor, and all the new industries, they added policing and prisons, regulation of industries (especially the strategically important railways) provision of water and sanitation in the new cities.

There were major changes in political control too. Between 1750 and 1900 Europe came to dominate the rest of the world. In 1800 Europe controlled about a third of the world's land surface, in 1900 over four-fifths. The stage was now set for the final chapter in this story – globalisation.

The disconnected economy: globalisation

The human story in the 20th century – especially in its second half – is of the cancer reaching its limits. With globalisation, human intervention on the natural world lost its remaining constraints, those of local cultures and governments. The driving force for most human enterprise has become the pursuit of monetary flows, an abstraction quite free from physical and biological requirements. Our impact on the natural world became so large that changes in weather patterns and climate became noticeable, and not just a scientific prediction, while the undermining of wilderness areas, fisheries and soil fertility is catastrophic.

The state of food production illustrates the situation. At the beginning of the 20th century, most agriculture worldwide was for local consumption. Local food was adapted to local conditions, so that every region had its specialities, season by season. Soil fertility depended almost entirely on manures and composts produced on the farm. But in the second half of the 20th century, food and farming became just one more industry, now using industrial techniques to improve the money flows through the industry. Through the use of farm machinery, the number of people required in agriculture dropped drastically. The use of larger machines led to larger fields and increasing dependence upon single crops, which were more susceptible to diseases and pests, and so were kept in check by chemical herbicides and pesticides. Productivity was increased by the use of chemical fertilisers. "The soil was treated less as a living organism

and more as a medium to hold crops in position as more and more chemicals were poured on to them."[16]

As an eminently marketable product, food developed in ways that enhanced its profitability rather than its effect on the health of people or the land. So highly processed foods appeared, with additives to prolong their shelf life. Fruit and vegetables lost their seasonal round. Limited numbers of standardised varieties are now shipped all over the world, replacing local varieties. Freshness, flavour and nutritional value take a poor second place to pristine appearance and suitability to industrial farming and distribution. High margin junk foods are the most heavily promoted. When did you last see a TV advertisement for fresh vegetables? Supermarket layout and design is a highly developed science; you can get PhDs in it. Atmosphere, lighting and smells are all carefully designed to put you in a receptive mood. Go into a supermarket in most industrial countries and you will find yourself in familiar territory.

Of course food is marketable only to people who have money. So land in Asia, Africa and South America came to be used to grow crops for export, leaving only the worst land for the poorer local populations. The result is a world in which billions go hungry while food is in plentiful supply. A domestic cat in the United States eats more meat than the average inhabitant of Africa and Latin America.

And it's not just food that has become globalised. During the early part of the industrial revolution wealthy individuals and families owned the new factories, mills and then the big retail outlets. They were still part of the local culture. The middle of the 20th century saw the rise of multi-national corporations which changed that completely. Professional managers began to run the corporations, and financial institutions – banks, insurance companies and pension funds – owned their stock. As global transport and

communications improved, it became possible and desirable (financially) to run a company that was distributed throughout the world. In the 1960s the Ford Motor Company in Britain made the Cortina for British use. In the 1980s its replacement, the Escort was designed for the European market and assembled in three plants incorporating parts made in 15 countries.

Large companies are now many of the largest economic organisations, dwarfing the economies of all but the largest nations. National governments have a very limited ability to influence them, as large companies threaten to move their production elsewhere. On the contrary, governments woo companies, offering financial inducements and freedom from social and environmental restrictions to locate in their territories.

Perhaps the clearest sign of how disconnected the human economy has become is what has happened to the financial markets. Before globalisation, the buying and selling of currencies was a necessary service to the rest of the economy. Now currency trading totally dominates world trade. With the abandonment of the gold standard by the US in 1970 and then the deregulation of currency transactions in the 1980s, all limits were removed. As late as the 1970s, the typical daily volume of foreign currency transations was in the range of $10-20 billion. On a normal day in 2000 that had risen to $2,000 billion. This amounts to over 150 times the total daily international trade of all commodities and services worldwide.[17] This is speculative trading, whose purpose is to make a profit from the changes in value of the currency. As John Maynard Keynes said:

> "Speculators may do no harm as bubbles on a steady stream of enterprise. But the position is serious when enterprise becomes the bubble on a whirlpool of speculation. When the capital development of a country becomes a by-product of the activities of a casino, the job is likely to be ill-done."[18]

With a cancer, unlimited expansion is all that matters. From the point of view of the growing cancer cells, it might seem great, "Our empire is expanding!" But from the point of view of the body, it means death and, ultimately, death to the cancer cells as well. All of humanity is currently caught up in the out-of-control, unlimited expansion that is our global cancer. Much of the problem is an unwillingness to look deeply enough and question the nature of our society.

The possibility of eGaia

Fortunately, as the cancer has reached its global limits it has also brought with it the possibilities of overcoming it. Several of the changes that made globalisation possible are also essential to a re-connection.

The late 20th century forced upon us a global view: a growth in environmental awareness, an awareness of humanity-as-a-whole through multi-culturalism and global television, some halting attempts at a framework for global peace, and most recently, a communications infrastructure which can enable humanity to function as a global nervous system, should it choose to do so. These possibilities form the contents of parts 3 and 4. Can we re-connect:

- with food, restoring our physiological link to the natural world
- in energy, so that we allow the Earth's climate to recover or at least stabilise
- in our economy, so that we act to promote the health of humanity and the natural world
- in thought and spirituality, so that we begin to form a single, global organism that could be eGaia?