4. Cultural Knowledge

4.1 Introduction

The evolution of sexual from asexual reproduction was a breakthrough in organism design. It allowed organisms to increase the rate of spread of new beneficial mutations. Through the differential survival of a succession of organisms, sexual organisms could more rapidly colonise a vacant niche, or more rapidly adjust to a niche of varying characteristics, than asexual organisms. The larger variation in offspring produced ensured at least some offspring survive. They could therefore out-compete asexual organisms, in some environments.

The next major breakthrough came with cultural knowledge; knowledge stored within the mind. A knowledge change need no longer be dependent on genes and so upon the generation length. Animals with cultural knowledge could out-compete those relying on genetically driven behaviours. They could adopt new behavioural strategies within their lifetimes.

This chapter will consider the evolution of cultural knowledge and, at the same time, make a comparison between this evolution and the evolution of genetic knowledge. It will compare the two knowledge processes. Clearly the methods of variation and multiplication are different for the two knowledge processes. This is to be expected given their occurrence in distinctly different environments. Yet, crucial to the comparison of these knowledge systems is, not their different manifestations in their different environments, but whether the underlying process governing their multiplication is the same.

4.2 Cultural Knowledge

Often the form an organism develops depends on the environmental information it encounters. An acorn, falling on open ground grows into a broad thick-trunked tree with ample lower branches while in a forest it has a tall slender trunk with few lower branches. Two different environments evoke two different structures. The oak tree is advantaged by having flexible genetic knowledge that takes into account environmental information during development. It is the distribution of light together with genetic knowledge that jointly determines the form of the tree.

If an organism's development is insensitive to environmental information, with it gaining some average form, then it will not survive in competition with other sensitive organisms that are flexible in form. For an organism, a genetic knowledge of likely environmental variations, coupled with an ability to adjust one's form and redirect one's actions based on these variations, is advantageous. As mentioned in section 3.10, this flexibility has been called by biologists 'an open program' or 'phenotypic plasticity'.

Flexibility in structures and actions is widespread. Flexible structures might be a bird adopting a white plumage during winter for camouflage in the snow or a fish hibernating by forming a cocoon in the mud should its lake dry out. Flexible actions might be a tree growing towards the light or its opening or closing of leaf pores in a response to humidity. Lorenz's paramecium did not wander aimlessly but choose its direction depending on touch and chemical scents. *Organisms take those actions that, according to their genetic knowledge, are best for them.*

Flexibility also includes feedback mechanisms. The mammalian body is kept constant in temperature by adjusting its internal temperature

through such actions as sweating or shivering. Different actions are taken depending upon variations in environmental information, in this case, the air temperature.

In all these cases of flexibility, the organism increases its chance of survival through a broad range of genetic knowledge that allows it a varied response to the environments it might encounter during its lifetime. But *change* to this flexibility can still only occur through new genetic knowledge in offspring. Change in 'flexibility' genetic knowledge is limited to the generation length.

If environmental information could be recorded *during* the life of an organism and this knowledge included in future decision making, then the organism's flexibility should be further increased. That is, if it can 'remember' past events, it should increase its chances of survival. It can now act differently depending on this recorded information. Offspring with new genetic knowledge for some mechanism of storing this environmental information should be advantaged. This brings us to the development of ***cultural knowledge*** that, in its broadest sense, could mean any stored environmental information that the organism can reuse at a later time. This stored cultural knowledge supplements genetic knowledge and any immediate incoming environmental information. Clearly, the word 'cultural' is suggestive of shared knowledge, but, as I will argue below, the first cultural knowledge was not shared, but for personal use. However, for convenience I will still retain the word 'cultural' to mean this non-shared knowledge.

Examples of early forms of cultural knowledge include the growth of the oak tree (mentioned above). At any stage of its growth towards the light source, new growth will depend in part on the tree's existing state. Environmental information has been stored in the *form* of the tree. How it grows at any point depends on both genetic knowledge *and* its form.

The tree's growth is from a combination of genetic flexibility and stored environmental information. Flexibility can be improved by the storage of environmental information. In contrast, the adoption of white plumage by the bird is the expression of genetic knowledge triggered by environmental information. Environmental information is not stored. The advantage of camouflage is known *genetically* by the bird, whereas the direction of the light is known *culturally*.

For the human, the storage of environmental information could be an increase of muscle bulk through exercise, a sun-tanned skin, or the formation of calluses. A change in structure has resulted from environmental information triggering the expression of genetic knowledge. For the muscle bulk, sun-tan or callus, further development depends in part on the state of the existing structures. The changes in the structures themselves *are* new cultural knowledge.

The reader might not be convinced that these examples so far are really cultural knowledge, or at least some of its earliest forms. More convincing should be an animal's resistance to diseases through antibodies. The antibody is made through the interaction of environmental information (the disease) and antigens (a substance that makes the antibody). The antigens exist through the expression of certain genes. Should the same disease attack at a later date, it will be much more easily resisted. A knowledge of the disease now exists; a knowledge not stored genetically. As well, this knowledge can sometimes be passed to offspring, through the placenta or through breast milk. The antibodies *are* cultural knowledge.

The chicks of some types of birds, particularly ducks, can imprint their mother's call or appearance in their brains. The chick has no knowledge of the mother's look before hatching. The chicks need some method to identify her if they are to follow her and get her protection. This

imprinting can occur even though a new 'mother' (substituted by the experimenter) may be of a different species and not look or sound anything like the natural mother. Environmental information is incorporated in the structure of the chick's brain during its development. The stored image or sound of the parent is cultural knowledge that directly affects the further actions of the chick, that is, it follows its mother.

In all cases, the cultural knowledge is stored in a genetic structure: the tree's form; the enlarged muscle cell; the pigment of the skin; the thickened skin; the chemistry of the antibody; or the imprinted brain. The emergence of cultural knowledge can be seen in the increasing reliance on stored environmental information to contribute to future structures and actions. The process of storing environmental information as cultural knowledge is the process of learning through experience.

The brain is an organ that evolved to specialise in the storage of environmental information. New genetic knowledge in an offspring that increased the size and/or efficiency of this organ would be advantaged (up to an optimum size, of course, as this organ takes energy to make and maintain - too large a brain may be a hindrance). With an increasing capacity for reusing stored environmental information, a succession of offspring might better compete with other organisms that encroach upon their niche.

Bees learn the layout of their nest surrounds in their search for nectar (Dukas and Real 1993, Chittka and Greiger 1995). Environmental information taken in by the bee's senses has become cultural knowledge in its brain. Naturally the bee also needs genetic knowledge to drive its mechanism (such as beating the wings), as well as environmental information such as the time of day (angle of sun), by which the bee knows the flowers are open. With this knowledge, it can achieve the feat

of relocating the flowers. But the bee is not limited to storing and recalling knowledge (Lindauer 1961). It can tell others of the flowers' location through a language of dances thereby transmitting learnt knowledge.

Some of this cultural knowledge, the position of the nest, the location of trees, and so on, could be called ***non-transmittable*** cultural knowledge. It is knowledge stored within the brain but is not transmitted to other bees. Each new bee must learn this for itself. Other cultural knowledge, like the location of flowers, is capable of being transmitted to other bees. This second type of knowledge could be called ***transmittable*** knowledge. It is only transmittable knowledge that can be units of evolution.

Apart from some knowledge exchanges among the social insects, almost all insect cultural knowledge is non-transmittable. An insect might learn about its surroundings, but it does not 'tell' others of this knowledge. In its evolution, the brain first enabled an animal to learn about its environment and vary its actions depending upon what it had learnt; *cultural knowledge evolved originally for personal use. The transmission of cultural knowledge to members of the same species was a secondary development.* This new use for the brain promoted nurturing, and eventually socialisation.

Cultural knowledge is knowledge not stored genetically. Like genetic knowledge, cultural knowledge allows an animal to better know its environment and reduce the indeterminism within that environment. An animal can avoid taking a particular action or avoid a particular environment that it remembers was detrimental on a previous occasion. Knowledge of this detriment was stored at the time and, if a similar environment arises, the animal can try a different action or escape from that environment (for example, foxes that have been hunted by humans

become particularly wary). As well as knowledge of detriment, knowledge of favourable environments and experiences can also be stored. Such experiences would include the location of food, water and so on.

The capacity to pass cultural knowledge came after the ability to store and retrieve knowledge. (Similarly, the capacity for the multiplication of molecules in the primordial pool came after the building of these complex molecules.) Having knowledge of an environment does not mean that that knowledge will be available to be passed to another animal. This is particularly true for animals that forgo a nurturing period and so do not inherit cultural knowledge from their parents.

Most fish do not nurture their young. Fish spawn can be liberated in the open water and become part of the plankton; it can be left attached to rocks; hidden in crevices; or even guarded in nests. Once the fish hatch, they must fend for themselves. Any cultural knowledge must be gathered through the fish's own experiences in their environments. Cultural knowledge is then accumulated from the environmental information experienced by the fish. This knowledge gained from experience is non-transmittable knowledge.

The fish learn through trial and error; they gain cultural knowledge through experience. For cultural knowledge to be exchanged between fish, knowledge would have to be transferred from one fish's mind to another. Fish will gain a knowledge by observing others but this is an indirect transmission. That is, the experiences of a fish, stored within its mind, must be expressed by that fish and this expression recorded by the sensors of another fish. Knowledge exchanges between fish are regular events although not necessarily intentional in the sense of a mammal nurturing its offspring.

An originally cautious fish approached by a non-threatening human diver, will soon lose its genetic caution (caution driven by genetic knowledge) and "learn" that the diver is no threat. "Learn" here means to accumulate knowledge of the environment within its brain and use this knowledge to override a genetic caution of being eaten. Knowledge has been stored about a particular animal; the diver. The fish will still show normal caution to other unfamiliar animals it encounters. The knowledge of the diver is cultural knowledge. A new fish, without any knowledge of the diver, will be emboldened by other fish it observes near the diver and so lose fear of the diver more quickly. Here cultural knowledge has been transferred to the new fish by the experienced fish. The new fish has learnt by observation of the experienced fish, although this exchange is not intentional on the part of the experienced fish.

Sometimes, what may appear to be a cultural exchange, is still only the transferral of environmental information. For example, a school of fish turning as one unit does not do so through an exchange of cultural knowledge between the fish. This movement is usually through an information exchange via the lateral line. Stored cultural knowledge within the brain of a fish does not drive such a movement. Rather it is a stimulus/reaction derived from environmental information. The resulting action is driven by genetic knowledge; a knowledge that caters for the majority of actions the fish are likely to require in their watery environment. A fish does not need to learn how to school, swim or bite as such abilities are innate (genetic).

While the school turns as one unit, the initial movement of a fish may be made by a particular fish that spies a predator (say). If this is the case, the sensory information (the image of the predator) may align with previous experiences of being chased and so the recollection of this chasing represents cultural knowledge. Here cultural knowledge will initiate a fleeing movement and this fleeing may then be further communicated to

the school through the lateral line. Alternatively, fish can communicate knowledge of a predator to other fish out of sight of the predator through "predator seen" body movements (Magurran and Higham 1988). This action no doubt contains elements of both genetic and cultural knowledge. The extent of schooling is related to the degree of predation.

Some fish can *learn* to avoid predators. For example, in some sticklebacks, the father attempts to catch the fish in his mouth and spit them back into the nest. The fry, by avoiding this catching, learn evasive responses that will be needed later for real predators (Huntingford and Wright 1993). The catching by the father is clearly a genetically driven action, while learning to evade is a cultural acquisition of knowledge. The father is genetically programmed to teach its offspring. Both genetic and cultural knowledge is needed to avoid predators. Experiences with predators will also change future actions taken by fish. Some fish can remember past experiences including learning to recognise whether a predator is hungry or not (Csanyi and Doka 1993).

Fishing from jetties is a popular pastime in Australia and a variety of fish are caught from them. The poles of the jetty are usually encrusted with sea weeds, corals and shellfish. This environment becomes a micro climate for a resident population of fish. The fish that can be caught from the jetty can be divided into two groups. The first is the resident fish which live permanently under the jetty. The second is the migratory fish travelling in schools which pass near or under the jetty from time to time. It is the second type the angler usually tries to catch. While he tries this the first type attempts to make a living from the bait that is offered to the second type.

The migratory fish always take the bait and hook (if hungry) and, even if they manage to escape, rarely learn from this and bite again at the bait.

They have a fixed genetic response to food and subsequently have not learnt to override this response with accumulated cultural knowledge. This is to be expected as they have little experience of hooks, having little exposure to them. In contrast, the resident fish are extremely hard to hook as they have the experience of being fished for regularly. They have learnt that there is a danger in swallowing an unknown quantity. As young fish they observed the actions of the adults long before their mouths were large enough to get hooked. Some species of fish (leatherjackets) are well aware of the "idea" of a hook and have mastered the ability to remove the bait from around it.

Now food with steel hooks embedded in it did not exist in the evolutionary history of the fish. The action of avoiding hooks is not a genetic one. The leatherjacket has the mental flexibility to learn by observation a new method of feeding. The fish's genetic impulse to swallow any bait at first sight has been overridden by cultural knowledge. Here cultural knowledge takes precedence in the decisions of the fish, at least in respect to feeding.

While fish show a wide range of behaviours they do not appear to pass cultural knowledge *intentionally* to other fish. There are instances where fish can nurture and provide food to their young (McKaye 1986) and where fish can recognise kin and avoid mating with them (Quinn and Busak 1985) but this is genetically driven rather than cultural. Fish can also care for and protect schools of their own fry. These parents are not adverse to kidnapping members of other schools, even of other species to increase the size of their own schools so as to lessen the chance of predation on their own young (McKaye and McKaye 1977). Fish may also help rear their parent's offspring (Taborsky 1984). Herbivorous fish have even been known to protect the young of a predator species (McKaye 1977). In these relationships, particularly the parent/offspring relationships, the young will experience the actions of their parents and

so learn from them. The drives underlying these actions are genetic and by learning from the parent the fry can add to this genetic knowledge a cultural component that may allow it to better know local conditions.

The intentional passing of knowledge is the next stage in the evolution of social behaviour. It usually occurs in that period of nurturing where the parent provides food and/or protection to its offspring. Greater quantities of cultural knowledge can be exchanged through this period and so a larger or better organised brain is required. The knowledge passed represents the skills that a parent has gained during its lifetime. For example, the caution a lioness shows towards porcupines can be inherited by her cubs without the need to experience pricks from quills. The cubs can observe and copy the parents caution towards the animal. Humans will also avoid many dangers without needing to experience those dangers.

Offspring usually need protection by the adult(s) during the nurturing period, for, unlike fish, they have incomplete genetic knowledge of their environments. This gap in knowledge they hope to fill with cultural knowledge learnt from their parents. Many birds are born with their eyes closed and need a substantial period of care before they are independent. Here the nurturing period allows the young to gain a structure with minimal risk of hunger or being eaten by other animals. In contrast, the domestic fowl provides little food for its chicks which start scratching immediately on hatching. The mother's role here is more one of protection and guidance that that of provider of food.

Being born helpless is not necessarily a handicap. The nurturing period will result in cultural knowledge being acquired that may give the animal greater flexibility in its behaviours than could ever have been achieved through genetic knowledge. A wider range of responses to various environments is possible. If there is no nurturing period, the

animal must rely on cultural knowledge that it can gain through trial and error. The niche of such an animal may be open to invasion by an animal of greater flexibility, that is, an animal that can nurture its offspring and so give them a more robust mental structure and an edge in behavioural flexibility. Such an animal will be selectively advantaged over a less flexible animal. The passing of knowledge from parent to offspring is clearly advantageous for generalists. A behaviour need only be learnt by trial and error once. Offspring need only learn it culturally, and so avoid dangerous experiences.

Externally, the cultural knowledge of animals can come from their parents or from their experience through interacting with their environments. Both sources of knowledge originated through trial and error. The next stage in the evolution of the mind involves "thinking up" new ideas without those thoughts being directly stimulated by environmental information. That is, possible events are pretrialed (Lorenz 1977) within the mind. For example, a monkey sitting in a tree can estimate, using stored knowledge, whether a branch will hold its weight. The monkey can imagine itself climbing out onto the limb and possibly falling if the limb is too weak. A potential action was pretrialed within its mind. By pretrialing events a generalist can more rapidly adapt to a new environment and minimise the physical risks taken in doing so. The risks are within the mind only. The mental process of pretrialing, thought, has become abstract. Animals that occupy a broad niche and pretrial actions have more flexibility in their response to their environments and so are selectively advantaged. Actions need no longer be tested through trial and error. Through pretrialing an animal can *predict* a detrimental outcome and so avoid it. Animals that are better at predicting events will replace those with a lesser ability for predicting events. The monkey, through cultural knowledge, can gauge whether a branch is too weak for its weight without ever needing to have fallen from a tree. Dangers can be avoided through thought (as well as

experience).

Lions not only accumulate cultural knowledge, but regularly pass this to other lions. A young lion may watch its parents hunt and so pretrial hunting within its own mind before it has a chance to practice on real animals. These skills can be honed by stalking imaginary prey. Such "prey" would include each other, very small animals such as frogs or insects, or even sticks and other inanimate objects. This "play" enables the offspring to be more prepared for animals that will present a real danger of injury, for example, through kicking hoofs or piercing horns. Experience is gained on "safe" animals. The lion is a generalist with an environment that can range from desert to forest or from human inhabited to human free. The lion will eat a wide range of animals for which different hunting techniques are needed. The variety within its environment will produce a variety in the cultural knowledge stored within its brain.

A zoo lion being rehabilitated, having had no mother to teach it, still automatically falls into a crouched stalking position when it sees game. Crouching comes from genetic knowledge. Though it may need some food initially after release from captivity, a lion will soon learn hunting by trial and error. Genetic knowledge provides the initial base for this learning. Cultural knowledge from pride members enhances and adds to this genetic knowledge. A zoo lion, without cultural knowledge, will still have some chance of surviving. If game is abundant, it will be able to survive on its own wits - that is, have an ability to accumulate and process environmental information. It will seek to increase its cultural knowledge of its environment. It may occasionally happen that a lion is abandoned at an early age, so being able to learn to hunt would be selectively advantageous.

Due to environmental instability (fluctuations in prey through drought

or disease), some cultural knowledge may only be relevant for a few generations, as a change in the environment may require new cultural knowledge. A lion is selectively advantaged if it is able to seek and obtain this new knowledge (this drive of curiosity will be considered at length later). The lion therefore has a genetic program that includes some essential features of hunting (crouching), but cultural knowledge taught to it by conspecifics, and learnt by it from its own experiences in its physical environment, is needed to supplement this genetic knowledge. If the cultural knowledge is not forthcoming from pride members, the lion must generate this knowledge through pretrialing possible actions within its mind, combined with the trial of these actions in real life, and discarding or modifying those ideas that fail.

Say a cub is practicing its hunting skills on a grasshopper. The insect has no cultural knowledge but acts innately, that is, through genetic knowledge. The cub chasing the grasshopper is experiencing aspects of the genetic knowledge of the grasshopper. For example, if the grasshopper takes one metre hops this will affect the chasing action of the cub. If the grasshopper takes half metre hops, there will be a different response from the cub. The cub learns about the genetic knowledge of the grasshopper. There has been a transfer of genetic knowledge of the insect to cultural knowledge within the brain of the cub.

A similar exchange will occur when the adult lion hunts a zebra (say). The zebra will calculate its fleeing movements from environmental information, genetic knowledge, and cultural knowledge. A particular movement of the zebra, say a decision to run in a certain direction rather than another, may depend upon cultural knowledge. The zebra may see broken ground, cover, open spaces and so on, during its run. It will choose that ground that it thinks will advantage it most. "Thinks" here means recalling actual stored knowledge, and then comparing this knowledge to its current situation, a situation being continuously

calculated during the run. This mental calculation may result in a change of direction for the zebra with a subsequent change in direction for the chasing lion. Here the genetic and cultural knowledge of the zebra has, in part, become cultural knowledge to the lion. The movements of the fleeing zebra are also environmental information to the lion. The knowledge has passed through the motion of the zebra to be detected by the senses of the lion. The lion is learning about the zebra's mode of fleeing. The chasing lion, if it gets too close, may cause the zebra to change tactics. The zebra has realised that the lion has greater speed than it first thought. Here cultural and genetic knowledge is passed from the lion to the zebra. The zebra is learning about the lion's ability to chase. The overall interaction results in a knowledge exchange between the two animals. Each animal gains a cultural knowledge of the other's genetic and cultural knowledge, though if the lion is successful in its hunt, the knowledge gained by the zebra is short-lived.

Persons befriending lions, like George Adamson (1968), rely in part for their survival on the accumulation of cultural knowledge by lions. The lions have learnt to see him as another lion, or at least a variation of a lion, overriding two types of genetic knowledge in the process. The first is the lion's natural (genetic) fear of humans. This may have evolved through the hunting of lions by aborigines, usually as feats of daring. The second type of genetic knowledge to overcome is the lion's perception of all other animals as food sources. George Adamson's lions have overcome their fear of humans and their perception of humans as a food source. Lions that have taken to eating humans have overcome their fear of humans yet still see them as a food source. Lions that have been hunted by humans become particularly wary of them and exceedingly hard to catch. Here the lions' fear of humans has been increased by the addition of cultural knowledge in the form of detrimental experiences from interactions with humans. Both properties - the fear or lack of fear of humans, and the perception of humans as food, can be passed to

offspring.

Adamson, in his interaction with lions, exchanges cultural knowledge with them. Lions can form real friendships with humans and genuinely enjoy their company. A person, as a de facto member of a pride, experiences most of the normal interactions that are usual between lions. This friendship is much more than a tolerance of their presence or the expectation of food. Lions brought up in the company of humans and returned to the wild have been known to seek the company of humans simply for the pleasure of their friendship (House 1993). This pleasure results from cultural knowledge being passed between lions and humans and through this a bond is made.

The size of the lion's brain is a response to the general environment in which it evolves. It is not necessarily advantageous for it to have a larger brain with greater reasoning ability. All the cells of an animal's body require energy to make and to function. A brain contains cells that do not directly aid in capturing or processing food and so the existence of such cells must be justified on performance grounds. If some cells represent a genetic cost, they will be eliminated by directional selection. The environment will select for the most efficient brain size for the lion, and its current brain size is likely to be near that optimal size.

If nature is "red in tooth and claw" where do animals find time to acquire cultural knowledge? Gaining knowledge is time spent that could be used in finding food and shelter or competing for mating rights, factors directly related to survival and reproduction. Habitats vary in their production of food. They are usually seasonal, with spring often the time of greatest abundance. Daylight hours are longest through spring and summer, ensuring an increasing throughput of energy and so a high growth rate in plants. Animals will give birth during spring. Predators will also give birth during in this period as it is the period of the greatest

increase in prey biomass. It is during this period of abundance that offspring are nurtured. As much knowledge as possible must be accumulated by offspring about their environments. Because of the abundance of food, many animals have free time, time that could be profitably spent in knowing their environments. A good knowledge of the environment will be crucial in times of hardship. This accumulation is necessary just to keep up with other animals, including competitors and predators, that are also accumulating knowledge about their environments (see the red queen effect, section 3.9). An animal would therefore be advantaged by maximising its cultural knowledge while it is young and has free time.

It is the times of scarcity, usually winter, that determine the carrying capacity of a region. Selection pressures are then at their strongest. Cultural knowledge and body structures (such as fat) accumulated during times of plenty are now needed to assist survival. Those animals with insufficient or the wrong cultural knowledge will fail. Such selection pressures act for increasing intelligence in generalists. Animals that can gain more and/or better knowledge during periods of plenty, will survive over those that have a lesser knowledge.

Generalists occupy diverse habitats and have evolved towards an "open" program. Lorenz calls "... rats from among the rodents, corvids from among the songbirds, and man from the primates, 'specialists in non-specilisation' " (1977:148). He considers the evolution of exploratory behaviour (curiosity) as the driving force for the development of abstract thought. Curiosity is of advantage to the young. Through curiosity animals explore their niche and gain a cultural knowledge of it. Animals not curious about their environments, will not know them and so be selectively disadvantaged later as adults.

But animals must not abandon themselves to curiosity so readily that it

endangers their survival. The level of curiosity needed is that level that maximises their survival through a gain in appropriate cultural knowledge. This optimum represents the most efficient amount of curiosity. For example, a lion cub that attempted to know a herd of elephants too well may forfeit its life. Yet one that ran from every elephant will waste energy and so be disadvantaged. What is necessary is that amount of curiosity that results in a "healthy respect" for elephants but not a fear of them.

Some species are more social than others. The degree of sociality depends on their life styles, that is, the niche they occupy (Creel and Creel 1995). As a general rule, the more cultural knowledge that is transferred between animals, the more social the species. Lions are more social than cheetahs and cheetahs are more social than leopards. These three predators have distinct lifestyles and occupy different niches. The leopard is a specialist for night hunting. While two leopards working as a team may well catch more game than one leopard, for there to be a directional pressure for socialisation, the average catch must be more than two. If the average is less than two, it pays for the leopards to hunt separately. Leopards, then, are solitary animals. Cheetahs also hunt singularly, relying on speed to run down a chosen animal during daytime. Yet cheetahs often form small groups and share food. This might be because the type of food caught, and so its volume, may also be a criterion for socialisation. Cheetahs are prone to having their food stolen by lions and hyenas and so it may be better to share many small meals between two or three cheetahs. By eating the prey no guarding of the meal is necessary. There may then be a directional selection pressure for socialisation for small groups where there is vulnerability to prey theft. The speed of cheetahs requires them to be lightweight and this may also limit the size of prey caught. Leopards do not have the problem of theft as they take game into trees away from other predators. For the African wild dog, pack size is optimum at around ten individuals (Creel

and Creel 1995).

The lion has the broadest niche of the three. It will hunt singularly or in groups, at night or in day. It does not have the speed of the cheetah and often relies on prey being ambushed. With a number of lions hunting, lines of retreat for the prey can be cut off. A communal hunt requires an exchange in cultural knowledge. The prey are usually large and a zebra (say) will provide one or two meals for a pride. If a single lion killed a zebra, all the meat could not be eaten in a sitting. Much energy would have to be spent to protect it. A single lion is also capable of being driven off by a group of hyenas and so these scavengers would be the greater beneficiaries of the meat. The pride system is a much more efficient way of sharing a large animal and protecting the remains.

The volume of cultural knowledge exchanged between animals is related to the degree of socialisation between them. A female leopard nurtures its young but after the young's separation all knowledge must be self acquired. Lions, on the other hand, will exchange knowledge throughout their lives.

It is interesting to note that the success of humans in forming friendships with a species is related to the degree of natural socialisation characteristic of that species, a degree related to the species' lifestyle. Life long friendships can be made with social animals such as elephants, lions and dogs, none of which are solitary (except some older males). These animals have the mental flexibility to include humans as members of their groups; quite an astonishing feat, as there would appear to be no phylogenetic history of such relationships. Friendships with cheetahs are not as strong as with lions, and leopards are quite unreliable in forming bonds with humans. The domestic cat, being in its wild form a solitary hunter more like the leopard, always has a certain remoteness (or aloofness) towards humans. There is no comparison between the deep

bonds that humans can form with lions and the shallow, almost utilitarian bonds, that are formed with domestic cats. The domestic cat is unable to fit into a social group where it is ranked. A cat does not accept a "pecking order". Yet this is crucial for socialisation within a group. "Each individual learns, by pleasant or bitter experience, which of its companions are stronger and must be avoided, and which are weaker and can be intimidated. In this way the "peck-order" originates, in which each individual in the group knows its own place (Tinbergen 1965:71).

Domestic cats and leopards, not being social animals in their adult forms, do not submit to a pecking order and so cannot be subjugated to humans. A domestic cat will only come to a call in expectation of some reward, food or being stroked, for example. A domestic dog will come because the human is perceived as being of higher rank in its social structure and so must be obeyed. In the wild, animals not submitting to the established social structure, may be expelled from the group. An expelled animal is less likely to survive. Expulsion cannot apply to solitary hunters which are more efficient as single units. A crocodile is even further down the scale of socialisation and there is no possibility of social bonds between two crocodiles, let alone between a crocodile and a human. The degree of "cruelty" imposed on zoo animals is related to their ability for forming social bonds. A social animal kept singularly is a cruel act. To keep a crocodile singularly is unlikely to be cruel. It will suffer more from the loss of environment and other animals than conspecifics (except possibly at mating time).

Humans are social generalists. They have been hunters, fishers, gatherers, scavengers, and agriculturists. The only plants not cultivated are those that grow too slowly or those that bare little edible product. Similarly, the only animals not hunted are those that are too small to eat, are inedible, or are too difficult to catch. Such a broad range of activity selects for great mental flexibility. Cultural knowledge is needed by

humans that is capable of driving behaviours to utilise this diverse niche. Humans exist in tribes, villages, clans, societies and so on. Solitary humans are a rarity, with a minimum group size being at least a family or a collection of families. Within these groups there is a well developed period of nurturing, with puberty of the teenager denoting the time when the young human is ready for independence from its parents (at least in cave times). This genetic age is overridden today by cultural knowledge due to an increase in the complexity of the environment, and so an increase in the amount of cultural knowledge needed to be absorbed before independence is possible from the parents.

The evolution of the complexity and size of our brains is evidence of the continual selection pressures upon humans for a greater ability to store cultural knowledge. That optimum of limitation for humans, between too large a brain and its genetic cost, may not yet be reached in evolutionary terms. Evidence for this is our rapidly changing cultural environment. Stability in brain evolution could be expected only in a stable, constant environment. Directional selection pressures may still, therefore, be acting for increased intelligence. But if this is the case, intelligent people should be selectively advantaged and should, on average, produce more children. While this is certainly true for much of our history, such a trend has in fact reversed in some instances over the last few hundred years, with environmentally aware, or career minded people, having the smallest families. Yet this reversal is of little consequence in the short term. A few hundred years is too short a time to see a genetic change in the brain. Evolution now is concentrated in the differentiation of cultural knowledge rather than genetic knowledge. For our purposes we can conclude that selection pressures acting on the genes, in respect to intelligence, are now so diverse as to constitute a "white noise". That is, there are many selections of the genes at the present time, but these are in many directions so no net change is likely.

Humans, of all animals, specialise in passing cultural knowledge from one to another. This knowledge passed is not necessarily through speech. Body "language" includes hand signals, eye movement, facial expression and posture. For example, consider the facial expressions of a number of distinct ethnic groups. Such expressions have real meaning. To frown at a child will bring about in a change in behaviour just as effectively as a spoken word. We could probably divide these expressions into sets according to such criteria as the style of expression, and the intensity and the frequency of expression. These sets will vary between groups. A person growing up in one group will copy that group's set of facial expressions. While expressions within the group will vary, for each expression there is an average intensity and frequency of use. None of the groups will have exactly the same averages. The same reasoning could apply to other body movements. These averages, for all body expressions, characterise an ethnic group. But the purpose of facial expressions is *not* to convey internal feelings arbitrarily (Fridlund 1991). Rather, expressions conveyed by people are strategies that they adopt in their interaction with their environment, just as the spoken word is well chosen:

> It is very costly to display one's intentions if one is committed to enacting them; by announcing one's actions, one risks the other's heightened resistance. Natural selection should thus extinguish such automatic displays. Displaying one's intentions can be advantageous if one is inclined but not committed to a specific course of action, and it is efficacious to alter or abandon one's course contingent upon that of the recipient (Fridlund 1991:21).

The evolution of the voice box gave humans the ability to communicate by sound. Through language it became possible to transfer knowledge, not through the eyes, but through the ears. This added a new dimension

to learning. A second advance occurred later, with our recording of knowledge through writing. Here transferral of cultural knowledge is again through the eyes. But there is a significant difference. The information transferred through books comes indirectly from another human mind, not directly. This allows information to be gained from persons the reader has never met, anonymous persons, and even persons that may be long dead. Through speech and books cultural knowledge greatly increased in volume.

An increase in cultural knowledge is not automatic, as it needs a flexible physical form. For example, regardless of the mental powers of whales, without appendages which can grasp little could be constructed in their watery environment should their mental ability evolve to an extent where writing was the next stage of their cultural evolution. A language developed could never be written down. Whales are intellectually limited by their physical form. Humans have not only the mental flexibility but also a flexible physical form. The use of the hands for signalling probably preceded human speech. Whales were once land animals and may have had a language consisting of sounds and/or "hand" signals. It is not clear whether these characteristics further developed in water, or whether signalling by sound started in water. Whatever the case, knowledge passed between whales can never be recorded and so its accuracy in transmission is reliant on memory. Human culture relies on the accurate transmission of knowledge through books rather than through memory. A teacher rarely memorises his lectures but refers to a set of notes as an aid to memory. Even more difficult would be the students' memory of the lecture in the absence of notes.

The process of the exchange of cultural knowledge has been expanding in human societies. Schools provide specialist teachers for a decade or longer. An enormous amount of cultural knowledge must be learnt in

our present culturally complex world. To get the protection of the parents and the society, a child must accept the current cultural averages of that society and also a ranking of social standing within that society (a pecking order). As Bischof notes:

> Among the familiar conspecifics providing security, the parents are of paramount importance because they are most strongly motivated to offer protection and assistance. But to get the benefit of their protection one has to accept their superior rank position. Thus a connection between security and obedience is pre-established. Moreover, in a human group the parental figures are the ones who are in possession of the traditional knowledge accumulated by the culture; it is from them that one hopes to receive all the remedies for emotional disorder and anxiety (1978:68-69).

While a child may override his inherited cultural knowledge in later life, his initial knowledge is from his parents and his society. He is bound to receive this knowledge as part of his attempt to survive. Language is taken completely from the parents. A child capable of absorbing a range of cultural knowledge, is confined to a narrow range defined by his resident culture. In this sense, cultural knowledge restricts a person to a narrow range of experiences, which may lead to frustration when a person later becomes aware of his cultural confines. Attempts to vary behaviour are often met with hostility by conspecifics.

So far we have considered knowledge initiated by environmental information, knowledge copied from conspecifics, and the pretrialing of events (abstract thought), all of which leads to new knowledge within the mind of an individual.

This applies equally well to humans as to other animals. Say there are

two primitive groups of people living near each other, but without contact. Both light fires in their caves, however by shear chance, in one cave the ground contains some metal ore which melts. Over time the development of this metal is such that this tribe has superior weapons. The tribe with the metal weapons succeeds over the other tribe in battle. Here a chance event has given a selective advantage to a tribe. It is not an advantage acquired through genetic knowledge. The discovery of the metal could be considered as a random cultural mutation that occurred through environmental information. I will assume here that the genetic knowledge of the two tribes is the same and that the discovery made of the iron, representing cultural knowledge, is the only difference between them. To take advantage of this discovery still requires an observant mind(s) if use is to be made of it. A certain mental ability is needed. But this is also true of a genetic mutation. The new mutation must be relevant in terms of the existing genotype. A genetic mutation that codes for some new behaviour is of little use if the structure of the animal is incongruent to this behaviour. Similarly, an environmentally led change of cultural knowledge must be interpretable in the context of the mind observing it. A lion observing molten iron after a fire could not use this knowledge.

(Iron has no doubt been discovered on many separate occasions by various cultures. This discovery may pass into the mythology of the tribe. For example, the Wadi artisans [of Chad] have a mixture of classical, Biblical and Koranic legends.

> Thereupon the angel sent them his son Sulyman. And Sulyman made iron malleable like wet clay and with his devine hands forged a helmet, a cuirass, and a sword. Then said he, Go now, ye are strong. And the men understood that iron was a gift from God and they could make of it tools for working and weapons for hunting and fighting (Lapie

1943:140).

Say there are two primitive groups of people living near each other, but without contact. Ore, happening to be at the base of a fire melts, and this metal is discovered after the fire has subsided. Later it is further discovered that this metal can be remelted and moulded when hot. Say also that one tribe develops iron technology while another does not. Over time the development of this metal is such that this tribe has superior weapons. The tribe with the metal weapons succeeds over the other in battle. Here a chance event, the discovery of the ore, has led to one tribe dominating another. I will give an example so this reckoning does not seem too fanciful:

> Iron ore is found in considerable quantities in the Fan country cropping out at the surface. They do not dig in the ground for it, but gather what lies about. To get the iron they build a huge pile of wood, heap on this a considerable quantity of the ore broken up, then comes more wood, and then fire is applied to the whole. As it burns away, wood is thrown on continuously, till at last they perceive, by certain signs, that they have made the iron fluid. All is then permitted to cool, and now they have *cast* iron. To make this malleable and give it temper, they put it through a most tedious serious of heatings and hammerings, till at last they turn out a very superior article of iron and steel ... As blacksmiths, they very far surpass all the tribes of this region who have not come in contact with the whites. Their warlike habits have made iron a most necessary article to them; and though their tools are very simple, ... they produce some very neat workmanship.
>
> The forge is set up anywhere where a fire can be built. They have invented a singular bellows, composed of two short,

> hollowed cylinders of wood, surmounted by skins accurately fitted on, and having an appropriate valve and a wooden handle. The bellows-man sits down, and moves these coverings up and down with great rapidity and the air is led through small wooden pipes to an iron joint which emerges in the fire. The anvil is a solid piece of iron ... The sharp end is struck into the ground, and the blacksmith sits alongside of his anvil and beats the iron with a singular hammer which is simply a piece of iron weighing from three to six pounds, in the shape of a truncated cone (Du Chaillu 1861:91-92).

The Fans were a very successful tribe in their region and, while this may have been due in part to their healthier climate (they were elevated and slightly inland, away from the influence of mosquito infested swamps), it was also due to the superiority of their weapons, which the availability of iron ore made possible.

> The strangest thing about the Fans (next to their hideous cannibalism) is their constant encroachments upon the land westward. Year by year tribes of Fan are found nearer the seashore; town after town is being settled by them on the banks of the Gaboon; and in the country between Gaboon and Moondah they have come down within a few miles of Point Obendo. In fact they seem a stirring race, and more enterprising than the Bakalai, Mbondemo, Mbicho, and even the Mpongwe; and I think will leave these gradually behind and take possession themselves of the whole line of seashore - where they may degenerate, though it is hoped they will not (Du Chaillu 1861:89).

The Fan were cannibals but this is to be expected in a warlike race. The constant warfare produces many victims that may as well be eaten (in

place of game that would have otherwise been secured had they invested their energy in that direction). As well, cannibalism was a form of terror that so frightened the non-cannibalistic neighbouring tribes that half the battle was already won on their reputation. (A similarity might be the Serbs' use of rape to terrorise their opponents.) Cruelty is an essential component to the success of warlike races. The reader might think all this a macabre turn and not see its relevance to evolution. But warfare and terror has been, and still is, an essential part of our evolution, both genetic and cultural. The human evolved in a climate of aggression. This is to be expected in social animals where the rank of an individual often related directly to its chance of survival and reproduction.

The discovery of the ore allowed the manufacture of weapons, and so the Fan's domination over other races, and no doubt led to their cannibalism. While the history of the ore's discovery is lost, the Fan were in the habit of having large fires and it is possible that some cast iron was one day found under one of these. The discovery and use of the ore underlies that essential property for success considered earlier as the pretrialing of ideas in the mind: curiosity.

Environmental information in the form of iron ore was converted into cultural knowledge in the minds of the Fan. This process required both luck and curiosity. If the tribe initially used wooden spear points hardened with fire, the discovery of the iron allowed them metal points. New cultural knowledge (metal spear points) successfully competed with old cultural knowledge (wooden spear points) for a place in the mind. The stimulus for the new cultural knowledge was the chance melting of iron combined with pretrialing possible uses of the solidified metal in the mind. The development of the iron required new knowledge to be generated from existing knowledge. This example will be developed further in later chapters.

The knowledge of the use of the ore is not stored genetically, but mentally. It is conveyed from generation to generation through mental contact. If the successful tribe, before the discovery of the metal, hardened their wooden spear points by the use of fire, this technique will now be replaced. The "mutation" that allowed new cultural knowledge (metal spear points) to enter has replaced the previous cultural knowledge (wooden spear points).

The example of the discovery of the ore is an example of environmentally led new cultural knowledge. The development and use of the iron to make tools and weapons requires abstract thought. Events (such as the spearing of an animal with a spear that has a metal point) must be pretrialed within the mind.

A person, knowing the working of a car engine, may "invent" or "imagine" a new variation of the engine. The working of the new engine has been pretrialed within the person's mind and his drawings. Only after the mind can go no further does it need to be tested through trial and error. Such new information within the mind is a cultural mutation or variation that is mentally rather than environmentally led. New knowledge has come through abstract thought. It has been initiated by other cultural knowledge rather than environmental information. These variations within ideas can be improved through their passing from person to person. Each person may make modifications to the ideas by thinking about them. The rate of variation in these ideas will depend on the gradient of the selection pressures acting (see section 3.11). As with genetic change, a rapidly changing environment is more likely to produce cultural changes than stasis. The colonisation of new environments, wars, revolutions, and so on, all provide a large gradient to increase the time spent developing new ideas through abstract thought.

A consultant who is paid by results or an academic competing for research grants, will both perceive an interest in cultural change. It is in their advantage to have a rapid change from old ideas to new. Many countries rushed to produce the atomic bomb as they believed their survival depended on it. Other countries saw economic power as more relevant and so created selection pressures for a rapid change in economic knowledge. Environmental pressures may increase the rate of new ideas thought up within the mind. For the use of iron, the stimulus for new cultural knowledge was environmental information. For "inventiveness" the stimulus for new knowledge is other cultural knowledge in the mind of the inventor. This knowledge may be previous inventions within the same mind or previously copied external knowledge.

Other changes to knowledge may be through random drift. Languages are always changing. A dialect is a variation on a general theme and this variation can come in a multitude of ways. Migration, colonisation, warfare, disease, catastrophic physical events, revolutions, religions, despots, and so on, may all separate or disperse a population into small groups. Over time the original language may vary, with these variations surviving differentially due to random drift. The languages of the Congo Basin are grammatically identical with the Bantu group (Ward 1910). However they also differ in word meaning, such that neighbouring tribes cannot necessarily understand each other. This points to the area being settled by one group that has divided into separate regions and, due to the restricted nature of their subsequent contact (through warfare and cannibalism), the languages became phonetically distinct. While the topography could be attributed to some of this change, at least some part of the differences between the languages would be due to random drift. The division of the world's language groups into Slavic, Germanic, Romance, Semitic, Indo-Aryan and so on, gives some indications of past movements of people. The dialects within the groups contain a large

element of random drift.

The success of humans in displacing other animals is due to their extensive cultural knowledge. Humans can "out smart" other animals. Surprisingly, this advantage does not extend to very simple animals such as bacteria and viruses, as their generation length is often quite fast, so they can change their genetic knowledge quickly. These animals are small so our cultural knowledge of their workings changes at a slower rate than their changes of genetic knowledge. Our brain evolved to solve environmental problems that can be detected by our sensors. Only the effects of small animals can be seen (with the naked eye), not so easily the animals themselves, making it harder to comprehend their workings. Some insects are also difficult to control by humans. While the insects can be controlled individually, their vast numbers preclude such direct control. Those insects that attack commercial crops soon gain a genetic knowledge of chemical sprays. The insect's sexual reproduction and consequent variety in offspring has ensured that at least some offspring will survive each spraying. These survivors are few and so the new crop represents an unoccupied niche to them. A high survival rate results from their offspring. Change in genetic knowledge can therefore outpace change in human cultural knowledge in respect to the toxicity of sprays.

An animal that can change its knowledge within its lifetime will be able to out compete those animals restricted to genetic knowledge. This knowledge, cultural knowledge, allows an animal to avoid actions that it remembers as unpleasant and to repeat those that are pleasant. Cultural knowledge allows an animal to know vacant and variable niches. Animals that nurture their young can pass cultural knowledge to them and so knowledge need not be learnt by trial and error for every animal. As the brain increases in complexity, abstract thought allows an animal to pretrial possible actions within its mind and so avoid detrimental trial and error interactions. Generalists undergo directional selections for sociality if it benefits individual survival. Sociality allows

knowledge gained by a group to be pooled. Such a group has more strategies to use in its interactions with its environments.

4.3 The Exchange Between Genetic and Cultural Knowledge

So far I have treated genetic and cultural knowledge as separate. I will now argue that they coevolve and exchange knowledge. Cultural knowledge can become genetic knowledge and vice versa. Such changes are, naturally, driven by directional and random selection pressures. While I will give some examples here, this coevolutionary theme is fundamental and will be referred to many times throughout this thesis.

In our polygynous tribal past, an individual who was stronger, more cunning, or more ruthless, often managed to have multiple wives and so more children. Intelligence and physical strength left better resources at his disposal to give to his children. Brain size and/or its calculating ability increased. With this developing brain came an increase in the amount of cultural knowledge stored within the brain. Social generalists accumulated and shared cultural knowledge. The increase was both at the expense of genetic knowledge and in addition to genetic knowledge. For example, hunting with spears is by cultural knowledge, and this knowledge has aided the collecting of living animals. The previous behaviours, say catching animals by hand (or not catching them at all), are largely driven by genetic knowledge. The use of spears represents cultural knowledge superseding genetic knowledge. If stones were thrown at animals before spears, then the throwing of stones would also have been driven by cultural knowledge. In this case the use of spears represents new cultural knowledge that has replaced old cultural knowledge (stone throwing). Due to the rapid accumulation of cultural knowledge, genetic knowledge is more likely to be overridden by cultural knowledge than replaced by it. A genetic knowledge of hunting has gradually been replaced with cultural knowledge.

Cultural knowledge modifies genetic knowledge. Glasses, televisions, telescopes, all modify eyesight; cars, boats and planes modify locomotion; farming implements modify cultivation, and so on. Cultural knowledge assumes some of the previous roles of genetic knowledge. This is precisely the reason for the evolution of cultural knowledge in the first place. It allows a variable environment to be known more rapidly, at a rate considerably faster than if restricted to genetic knowledge. Cultural knowledge is meant to replace genetic knowledge. Yet cultural knowledge does not form independently of genetic knowledge. The two coevolve. Had humans been half or twice their physical height, the televisions and cars would be different sizes and have different characteristics. The content of the cultural knowledge formed is influenced by our physical shape, brain size, communication mode, and all the other plants and animals we evolved with. These are, in turn, all influenced by the physical world we occupy (section 3.9).

Genetic knowledge influences cultural knowledge, while cultural knowledge will, in turn, cause genetic change. Animals, by choosing mates, a choice with a considerable cultural component in humans, directly affect the genetic make-up of the offspring. Like the fruit fly that looks for a vigorous dance in its mate, people look for mates that they think are "vigorous". But to gauge this suitability, people will rely to varying extents on current cultural beliefs. By this choice they have largely influenced the make up of any offspring. Mating could therefore be thought of as individual eugenics.

The cultural practice of selecting for better plants and animals in farming was well established before a knowledge of genetics or evolution. This applied just as well to humans as it did to animals. Malthus, some sixty years before Darwin's *Origin of the Species*, wrote:

> The capacity of improvement in plants and animals [through breeding], to a certain degree, no person can possibly doubt. ... It does not, however, by any means, seem impossible, that by an attention to breed, a certain degree of improvement, similar to that among animals, might take place among men. Whether intellect could be communicated may be a matter of doubt: but size, strength, beauty, complexion, and perhaps even longevity are in a degree transmissible. ... As the human race however could not be improved in this way, without condemning all the bad specimens to celibacy, it is not probable, that an attention to breed should ever become general; indeed I know of no well directed attempts of the kind, except in the ancient family of the Bickerstaffs, who are said to have been very successful in whitening the skins, and increasing the height of their race by prudent marriages, particularly that very judicious cross with Maud, the milk-maid, by which some capital defects in the constitutions of the family were corrected (1798:170-171).

Adolf Hitler attempted to take eugenics from the level of the individual to the level of the society. His intention was to encode a culturally conceived ideal human makeup within peoples' minds. This ideal would then become a directional selection in every person's choice of mate. The actions of one man, through his cultural knowledge, significantly affected the genetic characteristic of many people. Such a project of genetic change needed the removal of all those persons of "inferior" genetic knowledge. Here cultural knowledge has changed the gene pool and so the genetic knowledge of the population. This practice is not new. Many colonial governments ostracised those people who chose mixed marriages. Knowledge of this ostracism effectively reduced the number of such marriages and therefore affected the consequent genetic knowledge of the offspring. Aborigines were invariably repressed by

colonists. This is not surprising; like the village that discovered the use of iron, the strong invariably repress the weak. The colonists had better weaponry and more materialistically oriented cultures. Repressive measures on aborigines in countries used for agricultural expansion, particularly North and South America, and Australia, led to a decline in aborigines. In all these cases, cultural knowledge in the minds of some has led to the destruction of both the genetic and cultural knowledge of others.

Cultural and genetic knowledge exchange is not only between humans. The genetic engineering by humans of agricultural plants is a direct implementation of human cultural knowledge upon the genetic knowledge of the plants concerned. For example, say a wild plant has resistance to a certain disease while another cultivated species does not. The placement of the resistant wild genes in the cultivated plant is a change in the genetic knowledge of the plant, not by a natural genetic mutation, but through cultural knowledge within the mind of some humans. Human cultural knowledge, instead of the background electromagnetic radiation (say), is the mutating agent that is responsible for the change in genetic knowledge of the plant.

Cultural knowledge, as part of the environment of the genetic body, is often a directional selection pressure for genetic change. For example, the evolution of language may have been culturally "led". Say there is a group of apes that do not communicate by sound. One day one of the apes, upon hearing a bird, mimics this sound and by so doing introduces this as a signal to the group. The apes are able to make this sound although the mouth and tongue are an adaptation to biting and chewing. This signal is then passed from generation to generation and so would represent cultural knowledge. If the ability to produce this signal influences an ape's survival, an ape with a genetic mutation that allowed it to produce this signal with improved volume and/or quality would be

selectively advantaged. The new genetic knowledge would spread throughout the gene pool. One of the apes now, again by the chance hearing of a bird, makes a two tone signal. Similar genetic structures evolve as a response to this new selection pressure and so on. This process could be seen as a culturally led genetic change. Cultural knowledge has become genetically fixed. If this is the case, the voice box is, in part, a manifestation of cultural knowledge. Cultural knowledge was a directional selection that resulted in genetic change.

Naturally included here under culturally led genetic changes are random events. For example, the births of single influential individuals such as kings, popes, revolutionaries, scientists and so on, all have a random component to their birth. Such people go on to cause a significant shift in political events and so cause a significant shift in the content of the gene pool (through warfare, genocide and so on). The births of minor individuals also contain random factors resulting in small shifts in the gene pool. All culturally led genetic changes have a random component.

Genetic and cultural knowledge (like directional and random selections) can be seen as two ends of a continuum. Any structure or behaviour of an animal is likely to be driven in its expression, in varying proportions, by knowledge of both types. Each knowledge system is part of the environment of the other and therefore a selection pressure on it.

4.4 Mind/Brain Problem

Julian Huxley foresaw a move away from change through genetic knowledge towards change through cultural knowledge:

> Man's evolution is not biological but psychosocial: it operates by the mechanism of cultural tradition, which involves the cumulative self-reproduction and self-variation

> of mental activities and their products. Accordingly, major steps in the human phase of evolution are achieved by breakthroughs to new dominant patterns of mental organisation, of knowledge, ideas and beliefs - ideological instead of physiological or biological organisation. There is thus a succession of successful idea-systems instead of a succession of successful bodily organisations. Each new successful idea-system spreads and dominates some important sector of the world, until it is superseded by a rival system, or itself gives birth to its successor by a breakthrough to a new organized system of thought and belief (1961:16-17).

In conversations among people ideas are transferred from mind to mind. Huxley's "idea system" emphasises the evolution of ideas and ideologies yet he did not imply an equivalent mechanism for biological and psychosocial evolution. Richard Dawkins (1976) also considered ideas as evolutionary units. He coined the word "meme" as a unit of cultural knowledge analogous to the gene. Memes compete with each other for their retention within the brain. "Perhaps we could regard an organized church, with its architecture, rituals, laws, music, art, and written condition, as a co-adapted stable set of mutually assisting memes" (1976:212). A meme can only be a unit of transmittable cultural knowledge. Developing this further, a meme is a

> ... piece of information residing in the brain ... The phenotypic effects of a meme may be in the form of words, music, visual images, styles of cloths, facial or hand gestures, skills ... They may be perceived by the sense organs of other individuals, and they may so imprint themselves on the brains of the receiving individuals that a copy (not necessarily exact) of the original meme is graven in the receiving brain (Dawkins

1982:109).

The concept of the meme is itself a new idea-system, and whether it proves to be successful will depend on whether people are prepared to see it as a unit of evolution in its own right.

In section 4.2 I spoke of non-transmittable and transmittable ideas. Clearly only transmittable ideas can consist of memes. Non-transmittable ideas die with their owner and must be relearnt by each new offspring. However these non-transmittable ideas still form part of the environment of memes and affect their chances of multiplication.

For mental knowledge, I will retain the term 'idea' to mean either a transmittable or non-transmittable unit of cultural knowledge. 'Meme' will be used only where it is clear that the idea is capable of transmission.

(Strictly speaking, memes are not restricted to mental knowledge. Non-transmittable antibodies would also be ideas, and transmittable antibodies passed through placentas or breast milk would be memes - see section 4.2.)

One problem with the idea of the meme is that of its location. Some people believe that ideas can be external to the brain; that they are held in some spiritual sense. This leads to the mind/brain problem. Is there some repository of ideas separate from the brain? Dennett (1991:33-39) argues against separate locations. The spirit or soul must be non-physical otherwise science could locate it. Here I include energy as a physical substance. A spirit or soul could not consist of energy in a physical sense. If there is a place separate from the brain then a person must be able to communicate with it. But this leads to a problem - how is this communication made? Any transferral of information could only be

initiated by the brain. Yet the brain is physical and can only produce physical energy. How could something non-physical receive physical energy? If physical energy is transferred to a non-physical entity it must cease to exist at the non-physical location. Should it remain physical energy then the non-physical location would contain physical energy and so not be a non-physical location - an impossibility. The same problem also exists in reverse. How can a non-physical entity pass information to a physical entity? This would require energy which has physical properties. The problem leads, whichever way it is looked at, to a contradiction.

Yet there appears to be something significant in our minds that is separate from just the matter itself. Matter in the brain is ordered in a special way and it is this order that is different from just the chemicals themselves. The sum is more than the parts. In a plastic record the nature of the grooves contain certain information. The same record can be heated and remade to produce different music. A computer disk will contain different information if the pattern of zeros and ones on it is changed. In both cases the chemical content has not changed; rather the surface topography of the record and the polarisation of the magnetic molecules in the tape are changed. A person's mind contains information through the *order* of the elements within it; the elements themselves are not sufficient. The specific order is the achievement of the long evolutionary process organisms have undergone. One animal may be selectively advantaged over another, not because of any significant difference in chemical content, but because it has a superior order within its mind. It has a better knowledge of its environment. Here the order of the chemicals within its mind gives it greater adaptability. In this sense, as the phylogenetic knowledge of a species can be seen as an accumulation of a better order of amino acids, the cultural history of a species can be seen as an accumulation of better order of neuronal and/or chemical connections within the mind. Evolution is an ordering

process.

A person with a head injury may suffer a loss of knowledge through the order of elements being changed within the mind. Evidence for this is the many partial injuries, either through concussion or tumours, where the individual suffers a loss of memory only for that part of the brain affected. The nature of the affected portion has changed. If storage of knowledge took place in some outside entity, then damage to an area of the brain that caused a specific memory loss would have to be met by the argument that the damage also impaired a specific loss of communication with the non-physical entity. That is, different parts of the brain communicate separately with the non-physical entity. Such a proposition is too unlikely to be creditable.

Perhaps future research in brain function will resolve questions about the spirit. I will assume that there is no spirit or soul, and a meme, as a unit of knowledge, can only be stored within the brain. It is stored physically as chemicals and/or electrically as neural activity.

Evolution is an ordering process with this order representing knowledge. There is no spirit or soul separate from the body. The richness of the human personality and the sense of spirituality comes through the order of the elements within the mind.

4.5 The Analogy Between the Meme and Gene

Like the gene, the meme has the properties of multiplication, heredity and variation. It is a unit of evolution. In literature there is a common reference to an idea as a living unit. For example, clauses such as "the idea failed to get off the ground" and "it was a brilliant idea which took on" each refer to the idea as a unit of evolution. In the first the idea failed in its acceptance by other minds and became extinct. In the second, the

idea multiplied in new minds and spread. A new idea that is produced by a person survives differentially in the minds to which it is exposed. Only transmittable idea can be memes.

From section 4.2, the brain originally evolved as an organ to store environmental information for personal use. The transmission of cultural knowledge between animals was a secondary development. Where then is the *boundary* between memes and the non-transmittable cultural knowledge from which they arose? This boundary problem was encountered earlier for the case of the emergence of living chemicals from primordial pools. Clearly memes have evolved from mental pools of non-transmittable knowledge. Memes are living as they have, like genes, multiplication, variation and heredity.

Dawkins alludes to the meme as living by quoting a friend's reaction with which he seems to be in agreement:

> As my colleague N.K. Humphrey neatly summed up in an earlier draft of this chapter: "... memes should be regarded as living structures, not just metaphorically but technically. When you plant a fertile meme in my mind you literally parasitize my brain, turning it into a vehicle for the meme's propagation in just the way a virus may parasitize the genetic mechanism of a host cell. And this isn't just a way of talking - the meme for, say, 'belief in life after death' is actually realized physically, millions of times over, as a structure in the nervous systems of individual men the world over" (1976:206-207).

The idea of memes as living units of knowledge has not been widely accepted due the many apparent differences between genes and memes. However most of these differences are due to the different environments genes and memes inhabit, not to any fundamental difference between

these two units of knowledge.

In this section I will try and show an equivalence of the underlying processes in meme and gene multiplication. However, genes and memes are physically different entities with different environments. One difference that is immediately apparent in an analogy between memes and genes is that genes reproduce as a whole. That is, if an organism has a new mutation in a germ cell that bestows on an offspring a distinct selective advantage, then *all* the genes within that offspring will be equally advantaged, not just the beneficial gene. This differs from the multiplication of individual memes. Each is a unit of evolution in its own right and each is copied by another mind based on the scrutiny of each meme. The whole mind of one person does not multiply in another person. In this respect a meme behaves like the *whole* genotype of another organism. A better analogy might be to see the genotype as similar to a group of memes, say a particular religion or a branch of science. The memes that make up the religion or the chemistry, are generally taken as a whole by a person. Yet this analogy is still only approximate as few ideologies are copied exactly by another mind, in the same way that a genotype is copied exactly. Any analogy is further complicated by the fact that the genes of animals with brains reproduce sexually and so, while copying may be a fairly exact process, the resulting genes are themselves a mixture from the two parents.

Another approach is to bypass the organism altogether and to think of genes in terms of the gene pool. While the beneficial mutation above will result in all genes of the organism reproducing, in the long term the beneficial genes will come to dominate the gene pool and those of little survival value will be lost. This is similar to the reproduction of memes in the "meme pool". A single meme will also wax and wane in frequency depending on how often it is copied, and a beneficial meme will also come to dominate the meme pool. These two analogies, a genotype being

like an ideology, and fluctuations of memes and genes in pools, both have some validity though neither is exact. The use of either these analogies does not conflict with the main purpose of this section. This is to show that the underlying process of differential survival of variations occurring for memes and genes *is* Darwinian selection.

Say there is a new word created by a person (an idea). This word must survive in the minds of those people hearing it. "Slang words, however, sometimes force their way in to the language ultimately. Such respectable words as bus, hoax and mob were once slang. At the same time an overwhelming majority of slang words either remain slang or die an early death" (Aughterson *et al.* 1952:42). Here slang words are new variations that compete for acceptance in a mental environment, either spreading or failing. To Aughterson *et al.*, slang words are treated as living things, capable of surviving if they are accepted, dying otherwise. As we have seen, ideas are often referred to as living in the general use of the English language.

If the meme is living, then it is necessary to consider a meme's eye-view: "there are always several needs competing in the determination of current behaviour. As a rule, only one need can be met at a time; the others must be suppressed, at least temporarily. This feature alone gives rise to conflicts" (Bischof 1978:64). The mind can only direct one action (to satisfy a need) at a time. Each need, known culturally, is governed by ideas.

Here a new idea or an established meme "struggles" in its mental environment for expression. The exact mechanism of this struggle, commonly referred to as thought, is unknown. As considered earlier (section 4.2) an idea can come into the mind in three ways. Firstly, an idea can be learnt from trial and error through environmental interaction. Secondly, a meme can be copied from another mind or text.

Thirdly, an idea may come through abstract thought, the pretrialing of events within the mind.

New knowledge is gained through a variation of existing knowledge. A new idea is "thought up" by a person or copied from another person. In all cases, this new knowledge then "struggles" for existence in the brain. Now the brain is a genetic structure and contains many innate behaviours generated through genetic knowledge (see section 3.2). The new idea struggles with both memes and genes (through genetically driven behaviours). For example, a new idea for a fish "the diver need not be feared", must "struggle" with the fish's genetic fear of large fish (the diver being the large fish). The lions, for acceptance of a human friend, must overcome a genetic fear of humans. A person learning mountain climbing must overcome a genetic fear of heights. Earlier (section 4.3) it was emphasised that genes were part of the environment of memes and conversely, memes were also part of the environment of genes. In this struggle, an idea may, if accepted, repress other genes or repress or eliminate other memes. In short, the idea struggles with other knowledge resident in the brain. Of course it may happen that an idea struggles predominately with other memes, with genetic knowledge taking little part.

Some think that the complexity of this struggle precludes an evolutionary account:

> Evolution theory *alone* however, is not rich enough to capture the complexity of cognition. What is needed is a conception of theory structure which accounts for complex theory interactions such that the application of evolutionary theory to cognition employs other theories as links in complex causal chains (Thompson 1989:123).

But I disagree. The only knowledge of this mechanism needed is that ideas struggle in the mind and survive differentially. One does not need to know the *mechanism* of struggle, just as one does not always know the mechanism of an organism's struggle with its environment. But in all cases, that evolution occurs is clear.

A new idea, struggling for acceptance, will be in conflict with some units of knowledge and in harmony with others. An idea will be retained by a person if its *overall* payoff to the mind is positive (or, as will be argued below, it will be retained if it increases the person's happiness).

For example, the meme "drive under the speed limit" is adopted by most people. If these limits did not exist, many would travel faster. They stay under the speed limit as the negative payoff from the speeding fine outweighs the (perceived) positive payoff of travelling faster. Travelling under the speed limit returns (to most people) the highest payoff overall.

The new idea, once it has come to the attention of the mind, must now compete for retention within that mind. An analogy with genetic knowledge can be made. Imagine a number of vultures feeding from a dead animal. Each bird tries to obtain as much meat as possible. The birds will also try to avoid injury. Some will obtain more of the meat than others. Yet no new birds need be created or die in this process. Birds that fare poorly here may fare better on another occasion. As feeding is guided by genetically driven behaviours, then the action of feeding represents the phenotypes of the genes driving those behaviours. Success in obtaining food reflects on the likely survival of those genes.

Instead of birds, imagine ideas also in competition, with the length of time (prominence) ideas engage the attention of a person as a payoff instead of the volume of meat. Our experience of thought *is* the phenotype of the interacting units of genetic and cultural knowlege. No

ideas need be made or lost in this struggle. An idea that does not gain prominence in the mind at one time may be successful in some later environment (the mind at a different time). This phenotype of a idea, if developed fully, includes the external behaviours driven by that idea. For example, a chemist will only express his ideas on chemistry to other chemists. A particular idea in chemistry will be thought about and, if it seems of value, it will be told to others. The phenotype of the chemical idea is both the thought in the mind and also its external expression through words. An idea that is never expressed (not necessarily through language) can never be exposed to other minds and so has no chance of multiplication and so cannot become a meme. Survival in the mind is therefore not enough for an idea; only external expression gives it the chance of multiplication.

An analogy between biological evolution and the evolution of scientific ideas has been made by authors such as Popper (1959), Kuhn (1970) and Kantorovich (1989) to name a few. I will outline this analogy briefly. A person training as a scientist takes into his mind those scientific paradigms of the day and these become his core ideas. They represent an accumulation of past scientific ideas. Not all past ideas have survived. Those that have survived have been successful in being copied by the minds they were exposed to. The ideas have been modified and built upon; they have evolved. This is analogous to a phylum being a repository for successful genetic knowledge. Such knowledge represents phylogenetic knowledge. The scientist's research, and the research of his contemporaries, expose him to new data. If an account of these new data cannot be made in terms of his current knowledge, then he may "think up" new ideas to allow for it. The "new theory" results from the interaction between the old theories and the new data. It is an extension of his ability to pretrial actions. Here the new theory is the action and the environment of the action is the data. The theory allows the scientist a new perception of his environment (an environment that contains the

new data). If this theory is exposed to other scientists and it is accepted, then a new paradigm is created. This cycle is now repeated.

The analogy with genes is clear. New genetic knowledge (through mutation) that an animal has acquired in its germ cells has allowed that animal's offspring to better know their environment. New cultural knowledge (also a "mutation") has allowed the scientist to better know the data that he is examining. As these data are part of his environment, the new cultural knowledge has allowed the scientist to better know his new environment. In both cases evolution has taken place. Variations of memes and genes have differentially survived.

Some new theories will spread throughout the population while others will fail and be forgotten. Is this Darwinian evolution? Paul Thompson thinks that "evolutionary theory alone is not rich enough to explain our cultural evolution" (1989:123). Patrick Bateson, on the other hand, writes: "the Darwinian explanation for the origins of adaptations require variation in character, differential survival and a mechanism for the onward transmission of the surviving character. This principle can apply just as well to the production of ideas in the head of an individual or to the production of values within a culture. All three processes involve 'selection' in the sense that the version that works best is the one that survives" (1989:293). Schwemmler, in a book that encompasses our whole evolution from the original cosmos to humans, suggests that "the beginnings of cultural evolution (hunting in groups, tool making, language, tradition, writing, etc.) are thus interrelated with biological evolution (upright gait, increase in brain volume, changes in facial structure, and so on) in complex ways" (1989:159). While opinions are divided over the degree of congruence between genetic and cultural evolution, few authors do not recognise many elements in common.

At the same time, most authors fail to adopt cultural knowledge as

consisting of units of evolution independent from the genetic body. They consider the purpose of cultural knowledge to be one of increasing the adaptability of the genetic body. They see cultural knowledge as an adaptation such as a leg, the heart, eyesight, and so on. Cultural knowledge is to assist the survival of the genetic body. This was, of course, the original purpose of the brain. Stored knowledge can be used to better know the environment within an animal's lifetime. However as the volume of knowledge increased, and animals started sharing knowledge, the units of shared knowledge, memes, acquired an independence on their own. The living meme was evolved from a sea of ideas not yet capable of multiplication. As I will argue later, as this volume of shared knowledge increased in size, memes were able to invade that were detrimental to the genetic body.

The belief that all memes must be beneficial to the genetic body has led to confusion on the part some authors. Here mental ideas "do not have survival value, they can afford to contain, as they often do, even patently absurd assertions or to postulate bizarre entities like gods with incompatible characteristics" (Radnitzky 1990). Here the "do not have survival value" is a reference to the genetic body. The "bizarre entities like gods" is a reference to certain memes. The author has mixed the two, failing to see that goals of these units of evolution, individual survival, are separate. Authors who argue for cultural knowledge in terms of how it is beneficial to the genetic body include Lumsden and Wilson (1981), Bateson (1989), O'Hear (1989), Irons (1991). They do not see the meme as an independent entity in its own right. Trigg (1984), on the other hand, recognises the shortcomings of taking either an all-genetic or an all-cultural approach to the evolution of knowledge.

I will take a different approach. A meme, from its eye-view, has no direct interest in the reproduction of the genetic body in which it is resident. The meme's single goal is its own multiplication. The authors instanced above have failed to

see a separation of interest between genetic and cultural units of evolution. They insist on arguing that cultural beliefs sought are for the purposes of enhancing the survival of the genetic body.

In section 4.3 I argued that the two forms of knowledge could be thought of as the two ends of a continuum. Knowledge of one form can become, through directional selection, knowledge of the other form. The two forms of knowledge coevolve. Yet such a coevolution *does not* imply an overlap of interests between genetic and cultural knowledge just as there need not be an overlap of interest between two memes. The rabbit and fox coevolve but the interests of both are entirely selfish. There are no altruistic intentions in either. This relationship is not mutualistic. Rather, the fox can be seen as parasitic on the rabbit. The relationship between the cleaner fish (removing parasites) and the fish it cleans is mutualistic. Yet there are no altruistic intentions here either. The relationship between cultural and genetic knowledge contains both types of relationship. For example, cultural knowledge such as how to make fishing nets assists with the survival of the genetic body. The relationship is mutualistic. (I will extend the terms "mutualistic" and "parasitic" to also refer to relationships between two ideas or between an idea and a gene(s). "Bios" means life, and if memes are living the extension is justified). By contrast, cultural knowledge such as suicide destroys the genetic body (considered in section 4.9). The idea "suicide" is parasitic on the genetic body.

If a person sees some plant that he thinks will benefit him through its cultivation, he will take the plant, grow it, and assist its growth possibly by supplying extra water, nutrients and preventing predation. Here the thought "that plant is of benefit" is a new idea, the production of which was stimulated by environmental information. This new idea then interacts with the mind and, in case of our plant, has survived (as the person has gone on to grow the plant). New ideas that are perceived as

likely to return a positive payoff will be retained. Here the act of cultivating the plant is not some benevolent action in regard to the plant. It is a selfish one; a gain from the use of the plant is perceived. Now, rather than ideas generated externally by environmental information, imagine new ideas that arise from within the mind. These ideas undergo basically the same process. They interact with the current mind and are retained if they survive this interaction. The retaining of these new ideas is again no benevolent action; they are judged just as harshly as was knowledge of the cultivated plant. Should any of these ideas succeed in other minds, they are then memes and so new units of evolution.

As argued so far, many people make the mistake of taking a new idea to be an adaptation of the genetic body. A new idea is retained not because it aids the genetic body but because it survives in a person's mind. From the eye-view of the mind, it is retained because it returns a positive payoff. The new idea may be detrimental to the genetic body. (Similarly a new gene is not an adaptation of the genotype. It is a selfish unit of knowledge in its own right, a central argument of Dawkins, 1976.)

Ideas held by certain minds have survived in past mental environments. This survival does not depend on some abstract truth, rather survival only depends on the ability to persist after interaction with the mind. For example, the belief "the world is flat" survived for some time until overtaken by scientific memes. This belief survived in the minds of people at an earlier time, and although it could be considered the truth from the eye-view of those minds, we now know it to be false.

So far I have treated the meme as a unit of evolution, different from, yet being governed by the same underlying process as genes. A few authors have taken the meme as a unit of evolution in its own right, and the number doing so is increasing. They consider meme and gene multiplication to be the result of the differential survival of variations.

For example, Csikszentmihalyi (1991:11), who uses phrases such as "a religious meme directs" and "cultural mores recommend", is clearly adopting a meme's eye-view, thereby giving the meme autonomy from the mind. Here it is the meme that is directing the behaviours of the person. A person's behaviour may be governed by the memes inherited from others. Daniel Dennett also argues for memes:

> Memes now spread around the world at the speed of light, and replicate at rates that make even fruit flies and yeast cells look glacial in comparison. They leap promiscuously from vehicle to vehicle, and from medium to medium and are proving to be virtually unquarantinable. Memes are potentially immortal, but, like genes, they depend on the existence of a continuous chain of physical vehicles (1990:31).

In taking a meme as a separate unit of evolution, there is no implication that a meme is separate from the genetic body. It is stored within the brain, a genetically produced structure. The meme depends entirely for its existence on the brain. Yet the knowledge content of the meme is an independent unit of evolution. An analogy might run along these lines; for a person to drive he must have a car, but possessing a car does not determine the *destination* of the drive. The car could be the genetic body and the drivers, memes. Drivers compete for the use of the car. Different drivers may result in different destinations. Different memes may drive different behaviours for the genetic body. The car may have different drivers but they may all go to the same destination. In their struggle for the use of the car, some drivers may use the car frequently, others occasionally, and some not at all. Those that never use it will lose their ability to drive altogether.

This analogy is further complicated in that (from section 4.3 on the coevolution of genetic and cultural knowledge) the destinations of the

car will result in different modifications to the physical car (genetic body). The memes can affect genetic content. A person's choice of mate (a choice with a cultural component) will lead to a change in the genetic composition of offspring. For example, the "choice of mate" could be a driver and the destination, the unity with a particular type of person. Through a choice of mate different offspring result. Some societies' preference for male children has led to the infanticide of female offspring. Cultural knowledge has changed the gene pool. The type of driver (preference for male children) has resulted in a change to the car (the genes of the offspring).

The type of car may limit the type of drivers it can have and so the destinations to which it can be driven. The genes influence the type of ideas that can occupy the mind. Sports cars will attract different drivers than will utilities. A new mutation in a germ cell that increases a person's ability to understand mathematics (say) may lead to a career in mathematics rather than some other field. If, in this career, the person publishes new ideas on mathematics, the original genetic mutation has resulted in new cultural knowledge. The type of car has affected the type of driver and so the car's final destination.

Analogies made between genetic and cultural evolution have faced some criticism. I will now consider these criticisms and problems.

(1) Genes reproduce themselves directly whereas memes are copied by other minds.

Genes undergo direct reproduction in a similar way to the first multiplying chemicals in the primordial soup. Say one of these first life forms is a polynucleotide. For a polynucleotide to reproduce, it needs other specific amino acids in the solution around it. An adequate environment is necessary. Given this environment, the polynucleotide

can multiply itself through acting like an enzyme to bring amino acids together. In comparison, the meme within the mind achieves prominence, and, in so doing, expresses itself externally. This external expression is almost like "bait" to trap the mind of another person and so ensure the meme is accepted. How good the bait is affects the likelihood of it being multiplied. The meme, once in a new mind, will then interact with it and be accepted or rejected. If accepted the meme has multiplied. It is this "bait" stage that appears to be an indirect transmission of the meme. Does this indirect component indicate a separate process for meme and gene multiplication?

Consider the reproduction of an orchid. It may require a wasp to "mate" with a flower (that mimics the female wasp) in order to allow fertilisation from any pollen carried by the wasp. The flower's mimicking of the female wasp could be considered bait which needs to be taken by a male wasp (of the correct species). The orchid relies on the genetic knowledge (as well as some genetic ignorance) within the wasp for reproduction. This could only be considered a very indirect way of reproducing, a way that leaves the plant open to considerable risk. While in the evolution of its reproductive mechanism, the orchid may have taken the most selectively advantageous path at any given time, it has left itself vulnerable to environmental changes. Should the wasp become extinct for some separate reason, the orchid will also fail. The success of the orchid depends, in part, on the success of the wasp. Less specifically, flowers will also act as bait to catch bees and so achieve fertilisation. A grass may use the wind for its fertilisation. A fruit tree may exchange a meal for seed dispersal. Reproduction for plants and animals may rely, to varying degrees, on other plants and animals. Such a reliance could only be considered as an indirect component in the reproduction of these organisms.

An amoeba simply divides in two. Its cytoplasm provides all the

chemicals necessary for this division. It appears to have no indirect elements that could affect its reproduction. This may be true, but to achieve the state where it is ready for reproduction, growth in its environment was necessary, an environment that contained many indirect components in the form of hungry predators, lack of prey, and so on. These represent indirect components in other times of the life of the amoeba. An amoeba's reproduction, while it may seem a direct reproduction, relies on many indirect components prior to that reproduction.

Returning to our polynucleotide in the primordial pool, in acting like an enzyme it has receptive sites into which amino acids can lock. An unoccupied site could be considered as a trap waiting to snare an amino acid drifting by. The polynucleotide relies on an indirect element, the close presence of the correct amino acids, to successfully reproduce. Had the pool been depleted of a certain amino acid by a competing polynucleotide of a different type, our first polynucleotide may have failed to reproduce.

Like the reproduction of many organisms, the multiplication of the meme may involve a considerable chance or "indirect" element. It requires copying by another mind. Yet, if the meme is a beneficial one, this copying is not an unlikely event. The probability of some memes being reproduced may well be higher than the probability of some genes. For example, the child always adopts the language of the parents. It has no choice in this. At school there is little choice in learning, with punishment being received if memes are not taken in at a certain rate. Here, taking of the bait is enforced by the external expression of memes active within the minds of adults that make up the child's environment.

Earlier I argued that, as an animal interacts with its environment, it undergoes both direct and random selections. I have also argued that

animals with complex brains produce behaviours which are driven, to varying degrees, by both genetic and cultural knowledge. The reproduction of genes and memes can also be considered to contain both direct and indirect elements. Each represents a different end of a continuum with any particular reproduction containing some proportion of both direct and indirect components.

(2) What role do sensations play in this struggle?

Say a person puts his/her hand in cold water. If nerves in the hand trigger muscles and the hand is withdrawn instantly in a reflex action, then no struggle of genetic and cultural knowledge has taken place. Genetic knowledge alone has driven the action.

Should the person hesitate in withdrawing the hand, then environmental information (cold water) is converted to new cultural knowledge in the mind. The ensuing struggle between these new ideas and other genetic and cultural knowledge will change the state of the brain. The brain is a gland in which hormones are just as significant in controlling its states as neurones. Richard Bergland (1985) has given tables of many of these state-regulating hormones. Pain, love, happiness, rage, fear, and so on, are all manifestations of different hormones, or different combinations of hormones. The struggle of genetic and cultural knowledge changes the amount and type of these hormones and so the state of the brain, and the state so produced will in turn influence the outcome of further struggles of units of knowledge.

For our case, the person has a ***sensation*** of coldness. This sensation is a *state* of the mind in which cultural knowledge may play a part. A person acclimatised to the cold may have a different feeling of coldness than a person of tropical origin (like the sun-tanned person who has an altered susceptibility to sunburn). A person trained as a mountain climber or

commando may be more resistant to the feeling of coldness - memes have become resident in his/her mind that can override reflex actions. Cultural knowledge gained in the past can modify the state of the mind.

What about an emotion such as love? A man and woman might meet and be attracted to one another. For each person, environmental information, in the form of the other's features, mannerisms and conversation, is converted to cultural knowledge. The resulting struggle will include genetic knowledge for happiness, reproduction, or the satisfaction of family. The struggle of genetic and cultural knowledge, with its various hormonal releases, can produce a state of 'love'. If a couple are going to raise a family, then this bond of love is crucial. In cave times a male was needed to protect his mate and feed his growing family. For other animals, some form of love bond is present in all couples that jointly provide for their offspring.

Other hormones will also affect the state of the brain. The onset of puberty will alter its condition so as to preference some ideas in their struggle over others: more thought is given to the opposite sex. A new outlook on life will occur, with the evolution of this state being the transition into adulthood.

New and different states of the mind are the *effect* of the struggle of particular cultural and genetic knowledge. These states are not the cultural knowledge itself, and so cannot be transmitted to other people. However a person can describe these states, and how s/he obtained them. By seeking similar environmental information as given in the description, another person may be able reproduce the required state.

(3) Genes can be precisely located on DNA whereas a meme has no comparable position within the mind. A meme that is copied by a new mind is unlikely to be stored in the same way as in the first mind.

Dawkins himself suggests this might be a problem with the gene/meme analogy:

> Memes are not strung out along linear chromosomes, and it is not clear that they occupy and compete for discreet 'loci', or that they have identifiable 'alleles'. ... The copying process is probably much less precise than in the case of genes ... Memes may partially blend with each other in a way that genes do not (1982:112).

and on the other hand, the meme

> has a definite structure, realized in whatever physical medium the brain uses for storing information (1982:109).

While Dawkins sees similarities and dissimilarities, others see no hope for the analogy:

> ... none of these authors [Lumsden and Wilson, Dawkins] can provide a shred of evidence that culturgens, memes, or instructions actually exist as units in any independent sense at all, since they can produce no criteria for identifying them or for distinguishing them from other such units, unlike genes, atoms, and molecules (Hallpike 1986:45).

Similarly,

> Our definition of culture is not at all specific about the nature of the information that affects phenotypes. In particular, we do not assume that culture is encoded as discrete particles (Boyd and Richerson 1985).

Durham also sees problems:

> ... there are also major disanalogies [between genes and memes], the most important of which concerns the variability of the meme in scale and organisation (1991:422).

Despite these criticisms, I think the meme/gene analogy holds good. The activity of a mind could be seen as analogous to a *particular* primordial pool of interacting chemicals. As argued earlier, the chemicals within this pool interact, with different orientations and configurations occurring. Occasionally reactions form new chemicals. Some of these new chemicals are capable of influencing their own multiplication. For our analogy, in the mind there are many interactions. These interactions are our feelings, experiences and thoughts. New configurations within the mind that can drive external expressions are ideas. A self-multiplying chemical, successful in a particular primordial pool, may colonise another primordial pool if, upon landing in a new pool (through rain say), the multiplying chemical is successful in its interaction with the chemicals and other multiplying chemicals in the new pool. This is equivalent to the meme being successful in the new mind upon that mind's acceptance of it. Naturally the meme is stored in a different way in the new mind.

While a chemical is a distinct unit, it is unclear where a meme starts and where it stops in terms of the structure of the brain. Some consideration of this was given in the discussion of the mind/brain problem (section 4.4). Remember that a meme is a physical pattern in the brain and not the phenotype (conservation, writing, and so on) (Maynard Smith 1993b:108).

There are 26 letters in our alphabet and these could be thought of as the bases for the ideas that consist of words, phrases, concepts, rules and so

on (memes can also be body expressions such as frowning). These letters are also memes; memes that underlie all language. Letters are parts of more complex wholes. Words are the units which make up more complex ideas and these words are necessary for the linguistic transferral of any meme to another person. It may seem that memes are very vague concepts if they are nested in this way. Yet a similar structure occurs in genes. There are four amino acids that make up DNA and some 22 others that, as well as the first four, go to make up the cytoplasmic proteins, RNA and DNA. These amino acids are the bases of genetic knowledge. Amino acids that make up genes will also go, in a different order, to make up other genes. A particular amino acid that makes up one gene will differ in its effects on the development of an animal to the same amino acid that makes up a different gene. Like memes, genes are also made up of smaller units with vague borders. "Epistasis (one character being influenced by multiple interacting genes) and pleiotropism (one gene affecting multiple characters) are well established general phenomena rather than modifying curiosities" (Hailman 1982:215). Many phenotypic characters are untraceable to specific genes.

(4) While genetic variation appears to be through random mutations, variations in ideas are intentional. A person purposely seeks a solution to a problem.

When a person seeks to fulfil a goal, his thoughts are "guided" in solving the problem that he confronts. This apparently guided nature of thought appears to contrast with the haphazard nature of genetic mutations. Authors such as Stein and Lipton (1989) have tackled this problem by suggesting that the production of ideas in our minds is also, at least in part, random, with that randomness disguised through many thoughts being eliminated by unconscious selective processes. This creates the illusion that we are intentionally seeking problems to solutions (see also Campbell's [1960] analogy to randomness in vision). Stein and Lipton

argued that:

> If the evolutionary epistemologist is going to argue for a strong analogy between biological and epistemic evolution, he must provide either an account of how epistemic variations seem guided but are in fact blind, or an account of how biological variations seem blind but are in fact guided. We will do both, primarily arguing that epistemic variation is more blind than it seems, but also arguing that biological variation is more guided than is seems. We will explore two accounts of epistemic variation: the appeal to hidden chaos, which says that variations seem guided only because their underlying randomness is suppressed, and the appeal to epistemic preadaptation which says that the variations are guided, in that they are restricted by heuristics, but that these heuristics are themselves retained from a process that was mainly random. In other words, guided variation comes from retention - the retention of heuristics which are produced by previous variations. We will argue that not only do these two accounts work together to characterize the actual blindness and the seeming guidedness of epistemic variations, but, further, they are analogous to biological mutation and biological preadaptation. Hidden chaos is the epistemic correlate of biological mutation and epistemic correlate of biological preadaptation (1989:34-35).

The heuristics of genetic and cultural knowledge are those successful variations that are retained. It is these heuristics that make up the current genetic and cultural knowledge from which successful variations arise. Variations survive or fail depending on the directional selection pressures in the current environment (see teleology in section 3.12). Directional selections, though, are not enough for evolution towards

some vacant niche. There must still be variations favourable to movement in that direction. Earlier (section 3.9) I used the example of the cuckoo representing a directional selection pressure on the host bird. The host cannot move (through genetic knowledge) to expel the cuckoo unless there are favourable variations in genetic knowledge that can be selected for. It is possible for the host to expel the cuckoo through cultural knowledge, but for this to occur, the idea(s) that allow recognition of the egg and its expulsion would have to be taught to the host's chicks. If this was not the case, every bird would have to learn to expel the eggs itself within its own lifetime. (This does in fact happen in magpies in their recognition of chicks of the great spotted cuckoo. Yet each host must learn this recognition itself during its lifetime. It is not taught by its parents. [see Soler *et al.*, 1995]) As there are no cuckoo's eggs to allow a demonstration to chicks, such ideas would have to be communicated through language; a medium not yet sufficiently developed in the bird.

The ability of a mind to come up with new ideas representing solutions to problems depends not only on the genetic make-up of that mind, but also on its current cultural knowledge. For example, consider the generation of new musical ideas. Few people would doubt the existence of musical geniuses who show exceptional achievement at an early age. The ability to produce musical ideas has a genetic component. But this is not enough. The development of such a musical ability will only occur in particular environments that are characterised by leisure, musical instruments and pre-existing musical knowledge. These environments are conducive to the development of the genetic ability. A person growing up in a rich musical environment will produce a greater volume of musical ideas than the same person growing up in a musically impoverished environment. A background containing a large quantity of "musical" memes is more likely to form new musical ideas than a background of a smaller volume of memes. The provision of a rich

musical background for the offspring therefore contains an element of chance. Variations in culture, climate, friends, wealth of parents, and so on, will all affect the development of a musical person. All provide different opportunities to express musical ability. The occurrence of each has a random component. But all is not random. A part of a person's culturally driven musical ability may be inherited from his parents. If the parents are themselves musicians then they will probably aid the child with instruction. They will direct his development. Musical ability then, relies on both directed and random components.

A person needing to fix a machine may refer to a manual or another person. He may also "calculate" a solution from examining the machine. His mind now contains new ideas, memes that have come from outside the mind (the manual or person) or ideas from within the mind (through pretrialing). The meeting of people and the reading of manuals and texts all contain random elements. A person who has a mind rich in the knowledge of machines (machine ideas) and an ability to solve problems will require fewer new ideas to solve a problem than a person poor in machine ideas. (Similarly, a lion well experienced in hunting has an increased success rate.) The likelihood of new ideas therefore depends on the stock of existing ideas, as well as the genetic knowledge of the mind. Both random and directed components underlie the production of new memes. (Strictly speaking, an idea that is unsuccessful is not necessarily lost. For example, an idea that is an incorrect solution to a problem may be remembered so as not to make that mistake again. Here the idea is stored but is flagged as deficient. This deficient solution may even be taught to others so that they may in turn avoid the error.)

A chemist seeking solutions to a problem may consider a number of new possibilities (new ideas). After the interaction of these new ideas with the existing knowledge in his mind, those ideas represent the solution as his mind "sees" it. This solution reflects the condition of his mental

environment. A new chemical idea is more likely to survive in the chemist's mind (and so possibly spread to other minds) than a mind devoid of chemical knowledge. A mind rich in chemical knowledge will tend to produce chemical solutions to problems. In this sense, the chemist's prior knowledge "directs" his solutions to problems, just as a desert environment directs the organisms living within it to have water conserving features. Or, to put it another way, a chemical knowledge selects for chemical solutions, just as a desert environment selects for water conserving features. Here "select for" and "direct" have an equivalent meaning.

If a person says he "intends to do something" what does this mean? A chemist who "intends" to find a solution to a given problem will set out to achieve this. His "intention" is a state of mind, a state with a rich background in chemical knowledge. His mind will then direct his body to behave in a particular way depending on its knowledge. This direction will be to carry out certain experiments that lead to new data for his mind to process. If the chemist is given a laboratory with certain equipment, the components of the laboratory will make up his physical environment. His cultural knowledge will then express itself in this physical environment and the result will be new data. Had a different laboratory with different equipment been assigned, this different physical environment may have produced different or slightly different data. This environment and the cultural environment both direct the outcome of the experiment. This is the meaning of the phrase "directional selection". Here the environment "directs" one offspring to survive and one to fail. The "intention" of the physical environment (not a conscious intention) is to bring forth organisms that reflect the characteristics of the environment. Similarly, the intention of the mind is to bring forth ideas that reflect (or are sympathetic to) its genetic knowledge and other cultural knowledge.

To summarise so far, a person's brain with its initial genetic knowledge predisposes a person to retain memes sympathetic to that genetic knowledge. As a random element underlies this genetic knowledge, the same random element underlies the acquisition of cultural knowledge. Yet certain cultural knowledge (such as language) must be retained for survival. Other cultural knowledge may come through chance meetings with people and so there is a random element in the exposure of a person to cultural knowledge. The acquiring of cultural knowledge contains both random and directed components.

Having argued for a component of randomness in the formation of memes, it is now necessary to argue for a component of direction in the production of genes. (Clearly there is a random component in the formation of new genes - see section 3.7.)

The rate of genetic mutation in an organism will vary depending on the environment of that organism. Areas of low electromagnetic radiation such as caves, or areas of high radiation, such as radioactive radon gas emitted from granite sands, differentially affect mutation rates. If a lizard lying under a rock moves to a sunny position, then by a greater exposure to electromagnetic radiation, the probability of mutations within cells, including the germ cells, increases. Similarly, a lizard's consumption of one organism over another may, due to the different chemical natures of those organisms, influence the rates of chemical mutations within the lizard's body. An organism's physical environment influences the rate of its mutations. It could nevertheless be argued that, while this is true, the mutations are still random. Unless we can show that the lizard moved so as to *purposely* increase its mutation rate the randomness of mutations still stands.

Another possibility of a directed change in mutation rate is through genes that are capable of controlling the repair and multiplication of

other genes (section 3.7). If this is the case, the mutation of genes is not entirely random. In periods of stasis, where an organism is well adapted to the environment, a high rate of mutation, as mutations are more likely to be unfavourable than favourable, is a disadvantage. The structural and behavioural strategies of an organism in a stable environment are usually ESS, and so new variations would be eliminated. During periods of rapid environmental change, a high mutation rate would be of advantage as it will allow offspring more variability and so the chance of at least some of them surviving. An organism, in particular a generalist, will have a selective advantage if it can control the mutation rate of its genes. There is, then, a component of direction in the production of new genetic knowledge.

This same principle would apply to cultural knowledge. A generalist that produced a gene that increased, not a variation in the rate of genes, but a variation in the rate of new ideas produced, would cause more solutions to be "thought up" to environmental problems. The new gene may increase the structure of the brain and so the brain's overall calculating power, or, the new gene may be new genetic knowledge resident in the initial brain that makes up the environment of the incoming memes that are struggling for retention. Such a gene would be selectively advantageous. The resulting animal would be able to "out smart" other animals, achieving more resources and so increasing the number of its surviving offspring. An animal must increase its knowledge of its environment at least as fast as other animals with which it is in competition - the red queen effect - see section 3.9) This is, of course, the original reason for the evolution of the brain considered earlier.

So far I have argued that there are both random and directed components in the formation and multiplication of genes and memes. The components "random" and "direct" could be seen as two ends of a

continuum, with the formation of new knowledge being through some ratio of these two components. The ratio is a node on this continuum.

(5) Does cultural knowledge increase in complexity?

As argued earlier (section 3.11), there is an overall trend to an increasing genetic complexity in evolution. While this is the usual process, there are many exceptions (moles, cave organisms, and so on) where animals have become reduced in complexity. The same general rule that applied to genetic complexity applies to cultural complexity. Cultural complexity will increase if an animal broadens its cultural niche, and decrease if the niche becomes narrowed. The rate of movement from one niche to another will depend on the gradient of the selection pressures acting on the animal and the rate of variation of cultural knowledge. This is particularly clear in scientific knowledge which has continually expanded over the last few hundred years. While this increase has not been smooth there has rarely been any reduction of knowledge, except for the occasional fraudulent article where data has been manipulated.

Loss of complexity of cultural knowledge will occur if some despot or tyrannical ideological belief system represses knowledge. Reading material and the electronic broadcasting of information will be censured. Book burnings or restrictive journalistic practices have occurred in the past and are occurring at the present in various cultures. Such diminished communication has restricted the spread of cultural knowledge. On the other hand, excessive communication between groups may also cause a loss of knowledge. Colonisation usually results in local customs and languages being repressed or destroyed. The electronic medium of television, while informing people also acts as a "coloniser". It modifies or replaces local cultural systems with its own particular character. For example, many countries complain of the detrimental effects of the violence and the shallowness of television

programs that have been made in the United States. Humans, being social animals, will tend towards the cultural systems they are exposed to and this exposure includes the television they watch. Television is part of the environment of a person and so a directional pressure upon him.

(6) Knowledge that is acquired by people is passed to others, and in particular, their offspring. Is this Lamarckian inheritance?

> [Meme multiplication] is a sort of Larmarckian replication of acquired characteristics, as Gould and others have suggested (Dennett 1995:355).

Earlier (section 3.3) I argued that there may be some Lamarckian inheritance. I gave the inheritance of prions and viruses through the maternal germ line and the passing of antibodies through the placenta or breast milk as examples. The antibodies are not living entities as they do not have variation. They are ideas but not memes. The antibodies are a response to a variation in the environment. The antibodies are phenotypes of genetic knowledge, with this phenotype having considerable flexibility to modification by environmental factors during its lifelong "development".

The prions and viruses inherited through the maternal line are living entities. They have multiplication, variation and heredity; they are units of evolution. A prion's life may span several generations of an animal. Such an inheritance is Lamarckian from the eye-view of the offspring, yet it is not from the eye-view of the prion. It obeys the normal rules of evolution. It is an internal parasite inhabiting a number of hosts. These hosts are the environment of the prion. The prion can vary and these variations survive differentially. This variation is not constrained to a particular generation length; in particular it is not constrained to the generation length of the host. A meme shares some similarities with

prions and viruses. The lifespan of viruses, prions and memes can range over a number of generations and is not linked to the generation length of an animal. While memes and some viruses are passed externally, however, the prion and other viruses are passed through the cytoplasm of the germ cell. The synthetic theory accounts for the evolution of all of these units of evolution.

Much work on the inheritance of cultural ideas has been done by anthropologists. Cavalli-Sforza and Feldman give examples of cultural attributes, the spread of which is not necessarily related to the survival of an individual. For example, the practice of drinking Coca Cola may spread rapidly through a population. Basing their argument on the fact that these types of activities do not affect the survival of an individual, Cavalli-Sforza and Feldman conclude that "clearly, then, some kind of non-Darwinian selection is operating here" (1981:15). This type of error emphasises the difference between retaining a human eye-view of memes and moving to a meme's eye-view. Their argument is that a cultural drive (drinking Coca Cola) does not support the genetic body (nutrition from the drink). Yet a meme is not an adaptation of the genetic body and does not have a direct interest in the welfare of the genetic body.

The bottle and drink of Coca Cola is the phenotype of the meme "Coca Cola". A person's knowledge of Coca Cola includes his perception of the drink, what it tastes like and what it stands for. Drinking Coca Cola may affect, by some increment, an individual's cultural standing in that it confirms the individual as a member of a group. In the drinking of Coca Cola an individual performs a ritual that may assist social bonding. The sugar will satisfy a primal (genetic) need for sweet foods, and the water content will satisfy thirst thereby assisting the genetic body, at least to some extent. These characteristics are properties of the meme "Coca Cola". Should another drink be offered that has properties that are of

greater value and/or appeal, then it may replace Coca Cola. From the new meme's eye-view it has attributes that result in a greater positive payoff to the individual than the drinking of Coca Cola. It is this payoff that determines the continual acceptance of a particular drink. Darwinian selection still applies.

Many argue that the transmission of knowledge is Lamarckian (Cavalli-Sforza and Feldman 1981, Schilchner and Tennant 1984, O'Hear 1987) and characterise this condition as a significant difference between genetic and cultural inheritance. For example, ideas are passed from generation to generation and so this process represents the passing of acquired characteristics. The authors above have classified knowledge transferral into three types: lateral or horizontal transmission where ideas are passed between individuals of the same generation; vertical transmission where ideas are passed from parents to offspring; and oblique transmission where ideas are passed from peers of the parents to the offspring. There are immediately problems with this type of division. It is too constrained and exceptions can not be accounted for. Few parents would suggest that they had learnt nothing from their children. The passing of memes from the child to the parents could not be Lamarckian inheritance. Children also pass ideas between each other. A better model is the passing of a meme from any mind to any other mind depending on whether the meme survives the struggle in the new mind. From the eye-view of the meme, this is Darwinian inheritance rather than Lamarckian.

(7) Biological and cultural evolution differ significantly in their rate of change.

A meme can be exposed to a new mind, accepted by it, and later rejected and forgotten, all within the space of a few seconds. In the school classroom, numerous memes are multiplied in minds every day; few of these remain at the end of the day. Memes survive or fail at a pace

considerably faster than the generation length needed for genetic knowledge. This is, of course, the advantage of cultural knowledge over genetic knowledge and is the reason for its evolution in the first place. An organism that can think can more quickly reduces the indeterminism of its environment more effectively than a competitor restricted to knowing its environment genetically.

Like genetic knowledge, the rate of change of cultural knowledge will depend on the strength of the selection pressure and the rate of new memes to which a person is exposed. As argued earlier for the complexity of cultural knowledge, an animal moving from a narrow niche to a broad niche will undergo an increase in its rate of change of cultural knowledge. A person moving to a new country with a different language and custom will undergo a large increase in knowledge through the new lifestyle. People moving from broad to narrow niches will be reduced in cultural knowledge. Because cultural niches throughout the world are generally expanding, examples of reductions in cultural knowledge are rare. Possibilities could be enforced isolation such as prison, or self-imposed isolation such as becoming a hermit.

The proliferation of new ideas in our broadening niche is more like adaptive radiation than the competitive replacement of one idea by another. Many cultural niches are still unexplored. This is particularly true in science. The burst of discoveries in the physical sciences over the last two centuries, is due to this cultural niche being sparsely occupied. These discoveries have often brought fame and occasionally wealth. Yet the main human drive satisfied was initially that of curiosity, with immense pleasure accompanying each discovery (see section 4.2). The genetic drive of curiosity resulted in the evolution of the brain and so a drive for increased cultural knowledge. Greater cultural knowledge allowed the exploitation of new unoccupied niches and this gain allowed a selective advantage (through more food, shelter, mating rites and so

on). The human level of cultural knowledge, being far from sated, is increasing rapidly. To take advantage of this discovery still requires an observant mind(s) if use is to be made of it. A certain mental ability is needed. The seeking of opportunities, or curiosity to know one's environment, is advantageous for survival. Those people who exploit opportunities presented to them will, on average, obtain more materials, wives and so offspring. This leaves the human in a continual state of readiness to exploit new situations (Csikszentmihalyi 1993:30-32).

Cultural knowledge has resulted in an uneven improvement in food, transport and health and this has led to an explosion in population. However, the rate of change of cultural knowledge does not always reflect a similar rate of change in prosperity of the genetic body. A scientist may be so driven to pursue cultural knowledge that he neglects his family or is celibate. Knowledge of over-population has caused some people to limit their family size, an unusual act from a genetic eye-view.

The rate of evolution of *societies* also varies and will depend on such things as competition from surrounding societies, availability of food sources, frequency of climatic catastrophes, types of niche occupied and so on. "feudalism ... represents a lower level of general development than the civilisations of China, ancient Egypt, or Mesopotamia, although it arose later than these civilisations and happened to lead to a form still higher than any of them" (Shalins et al. 1973:33). Yet while a society, structured through various belief systems, may be a unit of selection, it is not a unit of evolution; only the meme is such a unit. The society is like the swarm of locusts or pride of lions. It is a convenience that improves an individual's chance of survival.

(8) The Will

The will is that faculty of the mind which determines whether or not we do something. How does this fit into the interaction of genes and memes as given above? The first question to ask is: why does anyone do anything? Of course the evolutionist would simply say that all those who did nothing have died out. Konrad Lorenz's paramecium knew what to do in its environment. When it found it could not go straight ahead, it changed direction. It did something. There was purpose in its actions, and while this purpose is hardly at our level of consciousness, there was still a momentum in its chemistry that kept it going. If this momentum is lost, death results.

In the human, there is genetic knowledge separate from the brain. It is in the cells of organs, muscles and bones. These cells work for the benefit of the body as a whole. Most are subject to regulation by hormones and nervous impulses from the brain or other glands. If the mind fails, and breathing stops, the cells of the body will gradually suffocate. Even so, a finger accidentally truncated can survive many hours, and can often be surgically reattached within this time. Its cells are still living. Like the paramecium, each little cell of the finger has a functioning mechanism of its own, and its death is only from those necessities of cell metabolism no longer crossing its membrane. The ongoing chemical momentum of the paramecium and the body cells are their wills.

As the cells of the brain are intricately interconnected neurones, it would seem that the firing of a few can awake many others. A neurone that acts on its environment (other neurones) is expressing its will. Like the paramecium, it knows exactly what to do. The wills of all these active neurones (electrically and hormonally) go to make the will of the mind. The will is our 'sense of presence'; that feeling we experience as ourselves. This ongoing interaction of neurones, the will, *is* the struggle to prominence of genetic and cultural knowledge.

Ideas struggle with each other for prominence within the mind they occupy. This struggle is thought. The meme is not necessarily an adaptation of the genetic body but an independent unit of life. The mind only retains a meme if it is in its selfish interest to do so. A meme, in expressing its external phenotype, may assist or harm the genetic body. The formation of new genetic and cultural knowledge is both random and directed. Feelings, sensations and experiences are unique. Like thought, they are the expressions of memes and genes and cannot be passed to other minds. At best they can only be described. Memes and genes are different entities acting in different environments so naturally they manifest themselves in different ways. Yet the underlying mechanism driving the multiplication of each is equivalent. Each has multiplication, variation and heredity. The struggle of genes and memes is the will of the person.

4.6 Game Theory

In section 3.15, I considered game theory. Contests involving a number of strategies were played with these strategies driven by genetic knowledge. Over time, the strategy which gave the greatest payoff (the ESS), became the dominate strategy with all other strategies going to extinction. Each contest played was considered as a new contest. I will now consider a contest where the players can "remember" the past strategies of other players (through cultural knowledge) and the payoffs from those strategies. Having the ability to remember emphasises the advantage of cultural knowledge. It enables strategies to be changed within the lifetime of an animal. The worm can only "remember" the strategy played by the bird (daytime feeding) through genetic knowledge. Its strategy is fixed for its lifetime. An animal with a memory can remember prior games that it has had and can adjust its responses accordingly. One contest of this type is known as the prisoner's dilemma. I will use a typical example (see Maynard Smith 1993a, Axelrod 1984, Grim 1996).

		Player 2	
		Cooperate(C)	Defect(D)
Player 1	Cooperate (C)	4,4	0,5
	Defect (D)	5,0	2,2

Player 1 receives the payoff on the left of the number pairs, player 2 on the right. If one player plays only D then it pays for the other player to also play D. By playing D he receives 2 instead of 0. If one player plays only C, it also pays for the other player to play D. His return is now 5. Hence D,D is an ESS. C,C is a strategy but it is not an ESS because either player can cheat and receive a greater payoff (5). Because of this short term gain, the system degenerates to D,D. It is the ESS that would result if players had no memory of the strategies played during the last contest.

D,D can be invaded if the method of playing the game is changed. In the hawk/dove game the opponents played with strategies with certain fixed probabilities. These probabilities are genetically driven and so are fixed for the life of the organism. A new game played with the same opponent does not rely on the results of the last game. Now consider that the rules of the game are changed such that the players can remember the outcome of the last game and play with this in mind. If a player knows that his opponent is going to play C, and will change to D if he plays D, then his highest payoff comes from also playing C. While he can cheat and play D and receive 5 points, his next play will be 2 when his opponent also changes to D. His average payoff for the two games is 5+2/2 = 3.5 whereas it would have been 4 if he had stayed with C. It does not pay to defect. The strategy of playing the previous strategy of the opponent is commonly known as Tit-for-Tat (TFT) and can invade the strategy D,D given a memory of past outcomes. The strategy of

player 1 is completely determined by player 2. Thus TFT is also an ESS under the new rules. These new rules lead to the possibility of co-operation (Wilson 1992). In these games it is important to be able to recognise the player and to remember his last response in the game you have just played. Without recognition the above game would degenerate to D,D.

Axelrod proposed a competition in which contestants could submit strategies for play using a payoff matrix similar to the one above. He found that:

> TFT won the tournament because it did well in its interactions with a wide variety of other strategies. On average, it did better that any other rule with the other strategies in the tournament. Yet tit for tat never once scored better in a game than the other player! In fact it can't. It lets the other player defect first, and never defects more times than the other player has defected. Therefore, tit for tat achieves either the same score as the other player, or a little less. TFT won the tournament, not by beating the other player, but by eliciting behaviour from the other player which allowed both to do well. Tit for tat was so consistent at eliciting mutually rewarding outcomes that it attained a higher overall score than any other strategy (1984:152).

If the contest is always with new players then nothing can be gained from remembering the outcome of the play. The outcome of the last game will not affect the strategy played by the new player. In this case it is best to play D rather than C. By playing D at least two points are gained. By playing C, there is a risk of no points. Contests will degenerate to D,D. This might explain why we feel comfortable dealing with the people known to us. We remember their strategies in past

contests and so the likelihood of their defection in any dealings we have with them. If they do defect we can retaliate against them in later contests or refuse to engage in contests altogether.

The Prisoner's dilemma is not a zero sum game such as a sports game where one side loses and the other wins. In these types of games keeping one's intentions hidden is as useful as an inefficiency in the other player's strategy will be to your benefit. With TFT it is an advantage for the second player to know your strategy. The best strategy against TFT is TFT. For example, some territorial birds develop TFT strategies with their neighbours. By reducing contests with neighbours, who have established territories and so do not represent a serious threat, the birds can concentrate on strange birds that may be directly competing for territory. A cultural knowledge of the neighbour's song is sufficient to distinguish it from other birds. The reduced conflict between neighbours is a TFT strategy (Godard, 1993).

Co-operative interactions are not limited to animals with cultural knowledge. While genetically driven organisms are not capable of recognising the players with which they interact, they can overcome this by making sure all interactions are with the same player. This can be done by maintaining continuous contact with the player. Take, for example, termites and their gut bacteria. If bacteria "defect" and digest the termite itself, they will destroy themselves. An animal that does not have continuous contact with its mutualistic partner, is open to defection.

The ability to remember the outcome of previous games leads to co-operation (reciprocal altruism) between players. A person who defects can be defected against, or avoided in future contests.

4.7 Artifacts

4.7.1 Genetic and Cultural Artifacts

Normally an 'artifact' is taken as a human made object. But this term can be used more broadly to mean any object resulting from the expression of genes or memes. Some artifacts resulting from the expression of genetic knowledge would include nests, burrows, webs and cocoons (Dawkins 1982).

A spider's web is made through its actions; actions driven by particular genes. The cells of the spider's body carry their own genetic knowledge, whereas the knowledge for web making is outside the web itself. The ability of the web to catch insects will reflect on the success of the genes that make them.

Other artifacts depend, to varying degrees, on the physical environment. An animal's burrow might vary considerably with its appearance depending on the nature of the ground in which it is built. Even so, the ability of the burrow to protect the young will reflect on the success of the genes that drive burrow making.

But what about the products of an animal's body cells, such as hormones, digestive juices, or teeth enamel? Like the web they are artifacts of the genes, but unlike the web, they remain as part of the body. All have multiplication, heredity, and variation through the external genes that make them, so in this sense they fit our definition of life. The success of these internal artifacts will also reflect on the success of the genes that make them. Carrying this argument further, the entire animal body could be seen as an artifact of the original germ cell.

Turning to artifacts made through cultural knowledge, these would include flints, clubs, spears, animal-skin clothing, fire, and the gardens of 'slash and burn' agriculture. Knowledge for the production of these artifacts was passed orally or by demonstration from parents to offspring, or, this knowledge was created in a single mind. Knowledge for the construction of later artifacts, such as pencils and cars, was stored not only in people's minds but also in various books.

How well a pencil writes and its appearance to the eye will become ideas in the minds of users. Both properties will reflect on its success in being purchased again or its recommendation to others, and so the likelihood of more pencils being constructed. These 'construction memes' are quite separate from the ideas generated from the use of the pencil. The construction memes are in the minds of the pencil's makers as well as in various technical manuals. Their expression can only occur if wood, paint, and graphite are available. The environment of the construction memes includes these physical needs, as well as the ideas generated in the minds of users. The further expression of these construction memes (new pencils being made) depends on their success in this environment.

New construction memes might lead to a pencil of slightly different characteristics. A different type of graphite or a different colour will change the pencil's characteristics. The new pencil now survives differentially in its environment of users. If this variation is more successful than the previous, it might supplant the earlier model.

Whereas the genetic knowledge for the web was in the body of one animal only, the memes for the pencil's construction are likely to be in the minds of many humans, as well as books; external to the artifact itself. Is the pencil living? In 3.2 I gave as a premise Maynard Smith's definition that something was living if it had the properties of multiplication, heredity and variation. I have already argued that memes

are living, therefore, the artifacts that they produce, like the artifacts of genes, will also be living. According to others, artifacts do not appear to have "needs" (Varner 1990) and artifacts are not organised from "within" (Monod 1971) and so are therefore not living. Others are impressed by advances in computer technology. Geoff Simons, in his book *Are computers Alive?* (1983), is convinced that computers are an emerging life form.

To further complicate the picture to this question of what is and what is not living, an artifact might be the product of both genetic and cultural knowledge. An elephant that digs a hole in a dry river bed may know through genetic knowledge that such an action will result in water being found. It can smell the water below ground. Like the burrow, its actions are the expression of genetic knowledge. If the elephant digs in a particular river bed that it remembers was successful for its parents, then there is a cultural component to the digging. New genetic knowledge in an offspring of the next generation for greater digging or smelling ability, or new cultural knowledge thought up in an elephant of the current generation for a better technique for digging for water, will both be advantageous for survival. The hole is both a genetic and cultural artifact.

On top of this, the environment, such as the condition of the soil, the presence of rocks, the depth of water, will all affect the nature of the hole and so the success in finding water. Another animal may broaden or deepen this hole making it an artifact of more than one animal. The hole is a coevolution of the physical environment and the genetic and cultural knowledge of a number of animals. Is this hole living? As it results from the expression of living units of knowledge, it must be living to some extent. The success of the hole will reflect on the success of the genetic and cultural units of knowledge that drive its construction.

Clearly the organisms of the world interact, no one is in isolation. There is then, a general coevolution of the world's living entities (genes, genetic artifacts, memes, and cultural artifacts) of the world. A good example might be the irrigation systems developed by humankind. The drive to eat is genetic. In order to grow food, irrigation was invented. It has been carried out through pipes, waterways and pumps, all artifacts produced by memes. Over time irrigation has significantly changed the physical environment in many parts of the world. Offspring of birds, fish, plants and insects, with an improved genetic knowledge of this new environment will be, on average, more successful. New cultural knowledge in humans has changed the genetic knowledge of other species. New memes may evolve for improved methods of irrigation more suitable to the changed environment, in turn further changing the environment, and so the genetic knowledge of the organisms, and so on. Genes, memes, and their artifacts, and the physical environment, all coevolve.

4.7.2 Remes

In cave times each hunter made his own spear. A boy would have copied or been taught the methods of his elders. Later, a metal spear tip was produced by an artisan. This movement to artifact production by specialists continued and much later, in today's societies, specialisation is the rule. Many people produce few, if any, of the artifacts they use.

A person using an electronic calculator is unable to make the device. Different parts of the calculator, the circuit, the plastic housing, the display, may be constructed by separate groups of people using independent methods. The calculator will be bought if ideas generated in the minds of potential purchasers from its properties succeed in these minds. Further ideas will be generated in their minds upon its use. If a state of happiness (or fulfilment) is the result from the struggle of these

ideas, then some ideas will become memes; satisfaction with the calculator leads to it being recommended to others. The new environment created by its sales will increase the chance of multiplication of its construction memes. That is, more calculators will be made to meet demand.

For some artifacts to evolve, a certain density of population was necessary. This is particularly true of complex artifacts that need numerous components, such as computers. There needed to be a critical level of different metals and plastics from which the electronic components can be made. An electricity supply was also necessary. Knowledge for the manufacture and use of all the various components had first to accumulate, while corporations of a certain size were necessary to absorb the financial risks (Grant 1986). Population growth and the growth of complex technology coevolved.

The algorithms (software) that run computers are products of the human mind; the algorithms are memes. One recent phenomenon is the occurrence of computer 'viruses'. These algorithms can be purposely written and let loose in computer networks. They may copy themselves onto a new computer, sometimes destroying useful information in the process, although most are benign. As products of the human mind, they are memes.

With the appearance of 'fuzzy logic', coupled with collecting environmental information (and so mimicking features of the human's sensory apparatus), computers are moving away from their earlier inflexibility. Some algorithms have been purposely written with the ability to 'mutate'. Here the algorithm itself makes a random change to its own code. These random changes are no longer memes. They are not direct products of human thought (although they rely for their existence on human produced algorithms). These changes could be thought of as

'mutations'. Should this mutated algorithm be able to copy itself to another computer, then it would have the properties of multiplication, heredity and variation and so be a new life form. To distinguish these units of knowledge from genes and memes, I will call them *remes* (which is an ancient form of 'realm', and signifies the new electronic realm of the computer [Hoerr 1996]). This new knowledge system is in its infancy, something akin to the first replicating chemicals emerging from the primordial pool. Remes are evolving from pools of electronic knowledge.

In organisms, gene change had a random component and those offspring with a better knowledge of their environments from this change survived, on average, more often. For the evolution of remes to occur a computer would need to be able to sense its environment. Those algorithms, though the addition of new remes, with a better knowledge of this computer environment would also need to survive more often. Algorithms would then struggle for survival in an electronic environment. Through a succession of algorithms, (or a succession of changes within the same algorithm), algorithm(s) will learn about their environments. If so, there is no reason why a computer mind, comparable to our own, could not evolve.

Could a computer gain consciousness some time in the future? An animal needs to be able to distinguish itself from its environment; a carnivore does not bite its own leg. It can see and feel its leg's movement and so is conscious of it. Probably consciousness is related to a critical mass of genetic and cultural knowledge. Few people would say that a baby just born has no consciousness. Yet it has not had any time to gain cultural knowledge. The consciousness of a baby increases with the growth of its brain and its accumulation of cultural knowledge, the collection of which is dependent on genetic structures.

Consciousness is a common event in nature. Birds, squid and humans, all make decisions based on accumulated genetic and cultural knowledge. They have evolved consciousness separately. Similarly, as the volume of electronic knowledge increases to reach some critical mass, consciousness could come to computers. This may still be some time away. Even if consciousness evolves, it is unlikely that these computers will ever be independent from humans. Computers will always need humans to make their electricity as well as many of their components. Similarly, humans will always need plants to manufacture carbohydrates from sunlight. The leaf is the most efficient converter of sunlight to chemical energy that we have and for humans to make food from this sunlight directly would not be practical. We will keep a parasitic relationship with wild animals and plants, and a mutualistic relationship with domestic plants and animals. Hopefully our future relationship with thinking computers will also be a mutualistic one.

The progression of genes, memes and remes suggests a series of evolutionary levels, or knowledge systems. Each level of life has emerged from the previous level and each level coevolves with all other levels. Each is characterised by a different unit of knowledge which is capable of variation, with this variation surviving differentially in its respective environment. It appears that a knowledge system, as its volume of knowledge reaches some critical level, becomes open to invasion by new knowledge systems.

After remes there may well be other knowledge systems, but what they will be can only be speculation. These knowledge systems are at least possible as the earth has some five billion years to go (a calculation based on the rate of the sun's nuclear burning). The process of evolution could then be characterised as that process which generates a series of nested knowledge systems. If remes and other knowledge systems evolve, then the human mind will have been a stepping stone along this path.

Summary: Artifacts result from the expression of units of knowledge (genes and memes). They reproduce through these units of knowledge and so are living. There appears to be a new unit, the reme, emerging in electronic environments.

4.8 Interactions of Entities and Groups

Genes or memes, or artifacts that result from their expression, could all be labelled 'entities'. All these entities are living, to varying degrees, and so are capable of 'offspring'. Cars, humans, ants and religions, are all entities which can interact, and the success of these interactions affect their chances of multiplication. Fortunately, regardless of the entities, there are only a few main types of interactions.

The interaction of most interest here is that between memes and genes in the mind. Some discussion of this was started in the second half of chapter 4. The second half of this chapter looks at this interaction in detail using sacrifice, fasting and suicide as examples. As well, the interactions of genes and memes dominate many of the later chapters, and so examples of these types of interactions will be limited below.

Interactions can be beneficial, detrimental or neutral from the eye-view of an entity. Some interactions between organisms driven by genetic knowledge alone were given at the end of chapter 2 and will again be referred to here to contrast with the interaction of entities driven by cultural knowledge. The interactions given below will be far from exhaustive. They are more of an overview of possible types of interaction and will help with more specific examples given in later chapters.

5 Different Types of Interaction:

1 Some Interactions Where Both Entities Benefit

An interaction between entities is beneficial if each increases its chance of multiplication as a consequence of the interaction. New genetic knowledge in the offspring of either for greater contact will be an advantage - up to some optimum of contact. Too much contact might no longer be beneficial.

If the interactions between mother and offspring are beneficial to both, a family unit with nurturing will evolve. The mother feeds and protects her offspring before their maturity and the offspring in turn reproduce their mother's genes. This unit will include the father if the father's interaction is also beneficial to all concerned. If interactions are beneficial between unrelated organisms of the same species, social groups, such as swarms of insects, schools of fish, and prides of lions, will evolve. If interactions are beneficial between members of different species, various relationships such as that between termites and fungi, or two animals sharing the same burrow, will evolve. All are cases of mutualism.

If the interaction between memes is beneficial, then belief systems will evolve. The meme 'life after death' supports the meme 'there is a god' in most religious belief systems. Each assists the other in its survival. The relationships among the memes of a belief system are mutualistic.

The construction memes that make the components of a car reinforce each other in the car belief system. The whole car as an entity, and its components, coevolve. A new mutation in the construction memes of a component that is beneficial to the mechanism of the car, will increase the car's chance of survival (being purchased). The construction memes of this component, as well as those of all the other components, have multiplied. Like the best genes coming to dominate the gene pool through sexual mating, the memes of the improved component will also readily survive in the pools of construction memes of other car belief

systems. This may not necessarily happen if these memes are prevented from spreading through secrecy or patents.

Another type of interaction is not initially beneficial to both entities, but can end up as beneficial. Where two people interact a number of times, each has the chance to censure the actions of the other on a later occasion. This can force interactions that are mutually beneficial. If one individual does not cooperate in an interaction, the other can retaliate by also not cooperating on a later interaction and so neither person benefits. They soon discover that their maximum benefit comes only when they both cooperate. These types of mutually beneficial interactions have been called *reciprocal altruism* (see Maynard Smith 1982, Axelrod 1984). They rely on remembering the outcome of past interactions. If an interaction is always with new individuals, then retaliation in some later interaction is not possible. An example might be the bad experiences people often have with taxi drivers or when exchanging currency on holiday - the opportunity to retaliate is negligible.

2 Some Interactions Detrimental to Both Entities

If the interaction between members of different species is detrimental to both, new genetic knowledge in offspring to avoid the other will be advantageous. If this competition is strong, the occupations of these species will become narrowed. Competition among the herbivores of the African plains has led to a narrowing of their occupations. For example, the black rhinoceros is a browser while the white rhinoceros is a grazer. Through competition they have diverged in occupation.

Divergence also applies to competition between artifacts. The struggle between different types of car is a struggle between different sets of construction memes (different car belief systems). The environment of these construction memes includes the ideas the car generates in the

mind of the potential buyer. Whether a car is bought or not will affect the survival of its construction memes. Strong competition will cause a narrowing of occupations with different 'species' of car (sedans, sports-car, 4-wheel drives, utilities, and so on) evolving.

In sexual animals, there is competition between members of the same species. This is not the case for asexual offspring where all are genetically identical so the idea of 'competition' among them has little meaning. Only if one has new knowledge through a mutation will there be real competition. Similarly with cars; like asexual reproduction, thousands of identical cars of one model may be made and there is no competition among these. But another model that has some different feature will initiate competition. The buyer will now choose between them, and this choice will advantage some sets of construction memes over others.

A competition such as a football game is a struggle between the belief systems (strategies) of each side, as well as a struggle between physical bodies. It is a struggle of both genes and memes. The memes of the winning strategy increase their likelihood of survival and so multiplying. New members entering a football club will be taught these winning strategies. Ineffective strategies may be lost, but not always. They may be retained simply for the purpose of telling beginners what not to do.

3 Some Interactions Beneficial to One Entity but Detrimental to the Other

Some examples given earlier that would fit into this category were a cuckoo and its host and a predator and its prey. In both cases one organism benefits from an interaction, while the other does not. Broadly, these types of interactions could all be called ***parasitism***. For survival, a parasite needs a host, and a predator needs prey. But the reciprocal is not true; the host does not need the parasite, and the prey do not need the

predator for their survival. This differs from competition where the disappearance of either interactant will benefit the other.

For a car, an artifact may be sold as a replacement part or an accessory, but it may fail in this role. A polish may not work, a seat cover may tear, or replacement spark plugs may malfunction. While there might be many different brands to choose from, a person has little opportunity to test the artifact until after it is purchased. This allows the construction memes to continue even though the artifacts they produce often fail. The deficient accessory needs the car to exist, but the car can survive without the accessory. Clearly the faulty artifact is parasitic on the person, but to be parasitic on the car, it must diminish the car's chances of being purchased. This may happen occasionally if the failure of the artifact deters a person from having a car altogether.

Memes that parasitise belief systems are also commonplace. A person might ask for a donation for god, but intend it for his/her own use. The memes in this person's mind are parasitic on the religion. The memes need the religion for their existence but the religion not only does not need these parasites, but may lose followers because of them.

4 Some Interactions Neutral to One Entity and Beneficial to the Other

Examples from chapter 2 were the cattle egret that gained from the insects disturbed by large herbivores, and epiphytes that gained elevation from trees. A car accessory, such as a cassette player of good quality (not parasitic), gains from the existence of the car, but the interaction is neutral in respect to the car. Religious memes, by driving the building of churches, will benefit these building memes. The church design memes need the religion, but the religion is not dependent on them.

The occupations of many animals do not overlap. Interactions either do not occur between them, or when they do occur the interaction is neutral - neither beneficial nor detrimental. A giraffe and a gazelle have different occupations and so there is no competition between them (although there may have been for their ancestors). The same is true for many memes. Memes for cooking and memes for religion do not overlap in their occupation. The two artifacts, cars and houses, also do not overlap in their occupation. The interaction between these entities is neutral in respect to their advancement.

Like the elephant which cleared areas of forest thereby indirectly benefiting animals that could now graze in the cleared areas (from chapter 2), actions driven by some memes will also benefit the multiplication of other memes indirectly. Ideas in a person's mind for setting up a business will indirectly benefit all the people who find employment from this venture, as well as the memes of the artifacts produced.

In section 3.13 I considered group evolution in respect to genetic knowledge. Here group selection resulted in group evolution only for those groups of genetically identical individuals. Termites undergo group selection (an attack on the nest, say) and group evolution through the nest's units of evolution, the genes of the queen. The termites all have the same genes and so the same units of evolution. This contrasts with locusts which, under harsh conditions such as food shortages, are selectively advantaged by swarming, a behaviour driven by genetic knowledge. A swarm of locusts undergoes group selection (by aerial spraying, say) but each locust is a unit of evolution in its own right. As the locusts have separate reproductive systems, selection on groups will allow some individuals to survive over others. Group selection results in

individual evolution. The swarm and the locust are both units of selection but only the locust is a unit of evolution. A village is a group of people. Each person is a distinct unit of reproduction and so, like the locusts, group evolution could not be expected here at the level of the village in a genetic sense.

People from the same village are more likely to have genes in common than people from separate villages. Therefore a person is advantaged by helping members of his own village, in particular those he is sure are kin. Unlike locusts, people have cultural knowledge which also consists of units of evolution. Even if there is no genetic relationship between two village members, because they live in close contact they know each other well and so remember, through memes, past interactions. These interactions are normally co-operative. By helping each other they can reasonably expect help in return, as their close proximity guarantees a long relationship. These reciprocal altruistic interactions bind a village together as a unit. In contrast, contact with an unknown member from a separate village may result in a defect strategy (D) being played. A history of transactions has not been established. There is a risk from cheats in dealing with unknown people.

Using the earlier example (section 4.2) of the discovery of iron, the knowledge of the making of iron is a property of certain individual minds, not a property of some village "mind". If a colonising village, with iron weapons "rapes and pillages" another village by killing the males and raping the women, then the knowledge of the iron would be spread to the conquered village. As well, the women taken as wives of the conquerors would ensure genetic success. Through the use of iron the conqueror's genes and memes would have been spread more widely. A conquered village, set up to reflect the characteristics of the conqueror's village, may look to an outsider as if the village itself has reproduced. But, while the village is a unit of selection, a village cannot

be a unit of evolution as there is no unit of heredity at the level of the village. What has reproduced is the memes that represent "iron knowledge" as well as other memes and genes of the conquerors. Characteristics of the village, such as the building style, layout, method of cultivation, and so on, are the phenotypes of memes brought by the conquerors. Like Dawkin's boat race where one beneficial mutation allows the multiplication of all the other genes in association with it, the iron meme has allowed the multiplication of all the other memes and genes associated with it. But the village is not a unit of evolution, that unit is still the meme.

If the knowledge of the use of iron is only known to a few individuals and should one of these individuals defect from the village and go to a second village, this knowledge will be passed to that village. The second village with its new weapons will be invulnerable to attack. The genetic and cultural content (except for the iron memes) of the two villages has remained the same. Had the second village not had the knowledge of iron, the rape and pillage of the village may have occurred and so led to a significant change in its knowledge. From this it is clear that the *way* memes are transferred between individuals can affect the memes and genes associated with them. In both cases there was an exchange of cultural knowledge, yet the outcome. That the second village was able to acquire the knowledge without suffering the associated memes and genes emphasises the meme as an independent unit of knowledge.

A new idea created within the mind or a new meme taken in by the senses, struggles within the mind for acceptance. It will be helped in its struggle by some resident knowledge and hindered by other knowledge. Memes that drive the tying of knots will support the memes for techniques in fishing. The memes for making iron spear points will be in opposition to and suppress memes for wooden spear points. The memes for cooking techniques are independent from memes for spear points.

Such relationships also hold between memes and genes. The memes for spears will align with the genes for making the muscles needed for spear throwing. Spear memes, by allowing food to be secured, will align with the genetic drive for survival. The meme for celibacy will act against the genes that drive reproduction. A meme supporting rape and pillage will align with all the genes. A meme for moderation in conquering, on the other hand, may also be successful in minds, but it will act against proliferation of the genetic body. Units of knowledge that support each other could be seen as acting mutualistically, and, if against each other, parasitically.

I now wish to turn to the idea of sacrifice. It results from the interaction of units of knowledge within minds. This has been a common event in the history of humankind, not just of animals, but of humans. It is spread across all cultures. For example, nearly all African races made sacrifices of animal and often of humans on important occasions. Consider the burial of a chief:

> Ten women, [in central Congo] the former wives of the deceased chief, with hands and feet bound, were dragged forward and placed upon the ground in front of the charm-doctor. Shortly afterwards a number of young men, formerly slaves of the chief, were also brought forward to the brink of the hole. Then amidst a scene of wild confusion the corpse of the great chief, now swathed in yards of cotton and grass cloth, was borne forward. Above the heads of the swaying crowd I caught sight of dark bodies being hurled into the hole. I could just distinguish the agonised shrieks of women - the unfortunate wives who were being sacrificed. The body of the chief was next placed in the hole. The crowd surged forward and swayed and shouted even more vociferously than ever when a hundred hands commenced to heave the

> earth into the living tomb of the chief's wives, who were thus buried alive. Hemmed in by the crowd, I found myself unable to retire from the horrible scene. The hole was soon filled in, and crowds danced on the spot. The first of the slaves was then brought forward. His head was fixed in a framework, suspended to an overhanging branch. A bright gleam of the executioner's knife, followed by a frantic yell from the multitude, denoted that the first of the numerous band of the late chief's slaves had been decapitated (Ward 1910:59-60).

The women and slaves were sacrificed out of fear that if the proper customs (memes of their belief system) were not followed a catastrophe might befall the village. It is easy to see how such beliefs and practices could arise:

> Darkness and fear so often go hand in hand. Fear was the constant companion of their night and days: fear of what their ancestral spirits might do to them; fear of a sudden death from one of the stealthy creatures that moved about the jungle; fear of the inscrutable powers of the witch-doctors - fears that, going back for uncounted generations, had now become part of their ordinary lives. The fear of these witch doctors was very real, for none of the Azande [a race of the Sudan] believed that anyone ever died from natural causes, but believed all deaths to be due to black magic. On this the witch doctor traded, and so great was the power of suggestion that anyone who thought that a death-curse had been put upon him generally gave up all hope and died (Jackson 1954:197).

By giving up hope and dying, the expectation of death is of sufficient strength to override the genetic drive to live. This 'expectation of death'

meme is cultural knowledge that has entered the mind and struggled successfully with other resident genes and ideas. The subsequent death is a form of suicide and the memes that drive it are in harmony with some knowledge (a belief in black magic) and in conflict with other knowledge (a genetic drive to survive). In contrast, the killing of the chief's wives and slaves are sacrifices.

To build on this concept of sacrifice, consider the previous example of the discovery of iron. Let us say that, through a confluence of certain events, a villager may form new ideas within his/her mind that a sacrifice must be made for the continued use of the iron with this sacrifice necessary to appease the 'god of iron'. Now why such a meme should arise is unclear. It may be that the person sees a gain in status and/or power through the idea. Sacrifice would be an impressive act to observers. On being told of the idea, people may fear death if the idea is not followed. As this idea, originally in one mind only, has now passed to other minds, it is a meme. A class of people, similar to the witch doctor above, might arise that is fed and cared for by the populace. For our purposes, this class of people could be called a 'priest class'. (I will use this idea of 'priest class' generally throughout the book to mean any class of people that possess unique knowledge, where this possession leads to an advantage over other people.)

> Before the battle of Salamis in 480 B.C., three nobles were sacrificed to him [Dionysus] by Themistocles at the command of Euphrantides the seer ...
>
> ... the Athenians slew the daughters of Hyancinthus at the dictates of an oracle when they were attacked by pestilence and famine (James 1962:78-79).

Here two people of a priest class recommended sacrifices firstly for the purpose of winning a war, and secondly, to conquer disease. We know, of course, that these sacrifices were futile, but at the time, for these people, it may have been considered a reasonable thing to do. What are a few people compared to saving many? This type of thinking allowed the proliferation of sacrifice memes. The memes were successful in their struggle of the minds of the people.

Sacrifice was believed necessary for a king or another prominent person to more effectively enjoy their afterlife:

> While the king of Ashanti's corpse was being washed, attendants were killed at each stage, to carry his bath-mat, sponge, soap, bath robe. At Porto Nova a principal official was the 'skin chief', and on the king's death this functionary was killed, skinned and the body of the king wrapped in the skin for burial. Another official announced the king's death from the roof of the royal residence, and then was shot down by an officer. Many of the victims were resigned to their fate and took poison as soon as the king's death was announced. Yoruba monarchs had special wives and ministers who were always known by the name which indicated that they would 'die with the king' (Parrinder 1961:126-127).

For the Aztecs, sacrifice was necessary to ensure the rising of the sun. Some of their sacrifices involved up to 18,000 war captives (Parrinder 1961). These sacrifices would take considerable energy as victims would need to be captured and subdued and this would reduce the time that could be used for growing food, building houses, and so on. Warlike nations ran the risk of becoming 'top heavy' with rulers, priests, acolytes, and soldiers. A continual supply of plunder and/or a well established slave class was necessary to produce the food for the non farming

component of the population. But all this has its limitations and a gradual increase in this non-productive proportion of a nation has caused many to eventually fail.

Sacrifices were also made as a test of faith. In Palestine the sacrifice of the first born was a common practice (James 1962). The Bible has God himself interfering, via an angel, to prevent Abraham's sacrifice of his son Isaac. These memes for sacrifice would have to be very strong in their struggle to overcome the genetic drive to preserve one's offspring.

Returning to our hypothetical 'god of iron' example, let us say that, through a confluence of certain events, a villager may form new knowledge (a mutation) within his mind which suggests that a sacrifice must be made for the continued use of the iron. Such a sacrifice is necessary to appease the "god of iron" (say). Now why such a meme should arise is unclear, yet historically, sacrifice was not only common, but arose independently in countless different belief systems. It may be that the person in whose mind the meme arises (and is retained in its struggle with other memes) achieves status and/or power through such a meme. Sacrifice would be an impressive act to observers. People fear death and may also fear the non acceptance of such a meme. The person directing sacrifice or some similar activity might be considered a "spiritual leader" and so the associated status would be selectively advantageous in his mind. A priest class might arise that is fed and cared for by the "working" proportion of the population.

If a certain member of the village is sacrificed, picked according to some formulae, then the memes that govern this sacrifice are not advantageous from the genetic eye-view of the victim. Yet the memes are advantageous from the eye-views of all the other villagers as they perceive a gain from the sacrifice (in this case falsely) through the continued use of iron. Although one member is lost to the village and this may evoke some fear

amongst those persons eligible for sacrifice, this loss may be compensated if the gain is the continued use of iron. This component of fear could be avoided by sacrificing a person captured in war who has been retained as a slave. By sacrificing a person not of the village the original "sacrifice memes" will have greater chance of acceptance by villagers. The perceived gain of the sacrifice is a property of the knowledge contained within the original sacrifice memes. The memes survive because they produced a positive payoff in the original mind, not because conveyed had some universal truth. Cultural knowledge, while it may result in negative payoffs to particular individuals, will evolve if it has a perceived net positive payoff in the minds of the majority of the people, or at least, in the minds of influential people. Here the village performs the sacrifice because it fears a greater loss if the sacrifice is not carried out. The memes governing the sacrifice are units of evolution in association that may reflect on the viability of the whole village. They could be considered as components of a primitive religion.

As argued so far, if a village with this religion or ideology then conquers a second village, the memes for the sacrifice may well accompany the conquerors. The memes are in a parasitic relationship with the memes for the use of iron (for other examples of parasitic memes, see Ball 1984, Goodenough and Dawkins 1994, Goodenough 1995). The "sacrifice to the iron god" allows the continued use of the iron. The sacrifice memes need the existing iron memes for survival, yet the iron memes do not need sacrifice memes (at least originally). The memes for the making of iron are mutualistic with memes for making spear points. All these memes are in association.

The restructuring of the second village, after the death of many of its male members and the impregnation of its female members, will include this new ideology in the minds of villagers. The reproductive success of the "memes in association" is similar to the success of the "genes in

association" (the genotype). It will result in the success of *all* the genes of that body even though success of the genetic body over another may be due mainly to specific genes. The success of the iron memes will enhance the success of all the other memes of the ideology. Villages that have this ideology will have a greater chance of survival than those without. If the villages fight, one village may survive over the other due to superior cultural knowledge. The villages appear to be acting as units. This is, of course, group selection, but it is not group evolution. The group does not evolve. The unit that does evolve is the meme and it is this meme that makes the group successful, just as the gene(s) for swarming enhances the survival of individual locusts under harsh conditions.

While there is selection on groups, this selection does not result in group evolution as there is no unit of evolution for the group. The unit of evolution is still the meme. Memes that increase the chance of the group surviving increase the chance of their own survival. A unit of evolution is an entity, and the interaction of these entities is many and varied. Memes that destroy the genetic knowledge of another person can successfully invade some minds.

4.9 Suicide and Altruism

I will now turn to suicide; probably the most extreme case where ideas occurring in a mind, as well as memes from outside the mind, have so totally overridden the genes of the victim. Memes that reach prominence and drive the act of suicide destroy the genes. In this example of suicide in Peru, grief was the main cause:

> So great was the ardour of the wives of the ruler and his attendants to accompany him to the tomb, however, that many of those that clamoured to be buried alive with him had to be restrained (James 1962:84).

Genetic and cultural knowledge struggled in the minds of these people and this struggle produced hormones for a particular state: grief. This state allowed other genes and memes to reach prominence resulting in the person clamouring to be buried alive. From a gene eye-view these actions are detrimental to their survival; they lose their chance of multiplication. The ideas that contribute to the suicide are *parasitic* on these genes. The suicide is a form of 'seeding' of these ideas. If these ideas become known they are then memes, as they have multiplied in other minds. If they achieve prominence in these new minds, they may lead to another's suicide.

In humans there is a drive to survive. It is clearly a genetic drive as it is common across animal species. For the person committing suicide, the genes for survival would have to be overcome by the suicide ideas in their mental struggle. This overcoming does not happen often so suicide is rare today, and was probably even rarer in ancestral *Homo*. Their cultural beliefs were simple and lacked sufficient complex cultural knowledge capable of overcoming this genetic drive to live. Suicide ideas would not normally get any help in their struggle from genes, except where a person was in great pain from injury or from old age with gene multiplication having already occurred.

Christ himself could be said to have committed suicide. He knew that his teachings could only have one outcome. In his own mind he probably saw his death as a sacrifice for the atonement of human sin. If a suicide is for ideological reasons, such as the burial of the attendants above, or Christ for his beliefs, then this suicide is self-sacrifice; martyrdom.

Suicide may also occur where an animal sees survival as hopeless and so gives up any hope of living. This 'giving up hope' and so mentally hastening one's own death well before any exhaustion or injury would normally cause death, has been demonstrated in rats. Wild rats collected

from slums were placed in water filled containers from which there was no escape (see Denton 1993). After thoroughly checking the container for escape routes and finding none, the rats drowned in a few minutes. By checking the container they gained cultural knowledge and this knowledge led to their early death. The rats died from a slowing of the heart which was inhibited in its action by hormonal transmissions from the brain. Perhaps the genetic drive to live was turned off - allowing suicide ideas to reach prominence in the mind. If these rats were rescued just before drowning, and if at some later time placed in the tank again, they were capable of swimming for 50 to 60 hours *in the hope* of being rescued. 'Hope' cultural knowledge played a significant role in their prolonged swimming.

A similar situation is seen in the human who has had a death spell placed upon him/her from witchcraft. The person gives up all hope of living and frets to death. Nothing but the removal of the spell will effect a recovery. The villager above who had a spell placed upon him and later died, did so because certain ideas for the expectation of death successfully struggled against his genetic drive to live. By giving up hope a person commits suicide.

In a contemporary setting, a vast and increasing amount of cultural knowledge is needed to function in our complex societies, yet the volume of our genetic knowledge has been relatively constant. All these interacting memes in the mind may overwhelm the genes. Financial problems, stress from too much work, or failed relationships, have all triggered suicides. There appears then, a correlation between the likelihood of suicide and the volume of cultural knowledge.

In 1978, a good proportion of the nine hundred residents of a community set up in Guyana, Jonestown, committed suicide (Black 1990). These people had been taught suicide by their leader, Jim Jones. Mothers even

assisted their children to take a deadly potion (this comes close to being a sacrifice of the children by their parents to verify the strength of their beliefs). These suicides and infanticides can not be explained by hidden benefits to genetic knowledge. Probably the most important memes used by Jones to achieve this feat were those for a belief in an afterlife. The residents believed they were going to a better place after death. The majority of these people would not have committed suicide had they not met Jim Jones. The colonisation of their minds by suicide memes resulted in their deaths.

The point that I want to establish in these examples of sacrifice, fasting and suicide, is that the memes that make up belief systems, or ideas thought up internally, can invade a mind, successfully struggle against its genetic knowledge, and drive actions that are detrimental in the eye-view of that genetic knowledge (in terms of its multiplication). Genetic knowledge can be inhibited or destroyed by cultural knowledge. While the destruction of genetic knowledge through suicide is not a common event, the repression of this knowledge by ideas is far more common and is a main theme of the next chapter.

Moving to altruism, an interaction between mother and offspring is mutualistic; both benefit from the relationship. The mother helps her offspring to survive and in return, the offspring multiply her genes. This type of relationship has often been referred to as altruism. It is not strict altruism in the sense of 'devotion to the good of others' without necessarily any benefit. Here the mother does receives a benefit. Another type of mutualistic interaction, also discussed earlier, was 'reciprocal altruism'. Here an interaction between people turns to co-operation because each has the chance to censure future actions of the other and so force co-operation. But this is not strict altruism either.

In both these cases, each benefits from the interaction. The altruism I will consider here is neither of these two. For strict altruism, the likelihood of the spread of the genes of the altruist must *decrease* through the interaction, while the likelihood of the spread of the recipient's genes *increases*. That is, the act taken by the altruist is detrimental to him/herself but beneficial to the recipient. Does this type of altruism exist? The earlier examples of suicide demonstrated that it was possible for ideas to reach prominence in their struggle and successfully drive acts that destroy the genetic body ('idea' includes 'memes' – see the section 4.5). Here an act is taken that stops altogether any chance of gene multiplication, but this act does not necessarily promote the genetic success of others. Even so, it should be a simpler task to argue that other ideas, not as severe as suicide ideas, can drive acts that are beneficial to others, while at a cost to the genetic viability of the altruist.

As a starting point, consider a Catholic priest's celibacy. Some memes within his mind suppress his genetic drive to reproduce, while other memes promote the helping of those under his care. This is nearly as bad as suicide from the eye-view of the genes, except that if the priest helps relatives, some genetic benefit could be possible. The reason given by the Catholic Church as to why celibacy is enforced is that it avoids distractions from family duties. The celibacy memes could be thought of as *parasitic* on his genes. The church requires its priests to look after the spiritual health of parishioners and to guide them back to the flock if they stray. Some people will benefit from the priest's actions and so increase their chance of having healthy children that will in turn pass on their genes. For the priest however, the celibacy memes prevent the spread of his genes. The priest's actions are therefore altruistic - but why are these celibacy memes successful in the first place?

Religions and other belief systems that promote help to others at the expense of reproductive success, are very complex in the sense of their

volume of memes. One condition for the success of memes driving celibacy might be this complexity. As I suggested earlier when discussing suicide, it is only in such a volume of memes that parasitic memes can compete against the genetic knowledge, achieve prominence, and so drive actions that increase the likelihood of their multiplication. This explanation might be partly responsible for altruism but it is hardly sufficient. Why will memes that promote altruism be selected over others that promote self-interest? To answer this, there is one more very important aspect to consider: happiness.

Struggles in the mind that result in actions that promote genetic success are rewarded with happiness; actions that reduce genetic success are punished with pain. These states of the mind result from hormonal releases in the brain (see *Sensations* in 4.5). I will take 'happiness' broadly to encompass pleasure, satisfaction or fulfilment. Fulfilment can actually result from an action that is painful in the short term but where a longer term benefit is perceived. Fulfilment includes: drinking when thirsty; eating when hungry; sleeping when tired; getting warm on a cold day; winning competitions; exercising; mating; and helping offspring.

The evolution of an association between genetic success and happiness is to be expected. An offspring with new genetic knowledge that gives it a hormonal reward when an act that promotes genetic success is performed, should be more successful. Through the differential survival of a succession of offspring, an association between genetically beneficial acts and hormones for happiness will evolve. *This association is so fundamental that it characterises all thinking animals.* Similarly, an association between acts that reduce genetic success and pain will also evolve.

The will of the mind (see section 4.5) is to achieve happiness, either perceived or real. Units of knowledge that succeed in their struggle do so

because they produce the greatest happiness, or promise to produce happiness at some time in the future. (The reader would be entitled to object here. I have earlier discussed suicide, surely this is not an action that results in happiness! But suicide can be a way to fulfilment. It is an action taken when all other actions known by the mind offer greater detriment. Suicide results in 'happiness' in that it is a release from greater pain, either imagined or real. The people of Jonestown opted for suicide because they saw it as a method to pass from living in an unsatisfactory world that generated only pain, to a new utopia. For them, the memes for suicide offered a greater long term happiness.)

Happiness and genetic success went hand in hand in our cave days (it still does in other animal species). A person's goal of maximising happiness was a goal of maximising genetic reproduction. In the contemporary person, memes are able to invade and subvert this relationship. Take mating for example; it is rewarded by orgasm and other associated pleasant feelings that come with the release of hormones in the brain. The genetic knowledge for orgasm evolved in an environment where mating always led to children (given no medical abnormalities). In contrast, the contemporary person has a range of artifacts (condoms, diaphragms, pills, and so on) which can prevent fertilisation. Mating need not now lead to children. Memes that produce these artifacts have allowed more frequent mating, often with a greater number of partners, resulting in greater volumes of hormones released and so increased happiness. Through these artifacts, *a person gains a genetic reward without the genetic consequence.* The contraception memes have parasitised the original genetic drives for this action. On the other hand, a person can achieve greater happiness through the use of contraceptives. This parasitism by memes is much less severe than memes for suicide or celibacy as the use of contraceptives is usually only to limit the size of the family, not the complete avoidance of children. (Another way of obtaining this happiness directly, at least in the short term, is through drugs. The drug

itself acts on the brain in a similar way as to hormonal rewards. Should the use of drugs result in no children, or children that are poorly looked after, then the drugs are also parasitic on the genes.)

Just as there is a genetic reward for mating, there is a genetic reward for another major drive: helping offspring (earlier referred to as kin altruism). Parents get fulfilment in seeing well adjusted, happy children - children likely to be good parents themselves and so continue the multiplication of their genes. Parents are driven to feed and teach their children. Like the contraception memes, some memes such as 'love your neighbour' can often invade this relationship. They gain for the mind the same genetic rewards (hormonal releases) for help given to non-related people. There need be no expectation of this help being reciprocated. The person gains the same genetic rewards as if s/he had helped related individuals. If this help to non-related individuals is at the expense of help to offspring or other kin, then it is altruism in the strict sense mentioned above. The help increases the chance of the genetic success of an unrelated individual, but may lower the chance of genetic success of the altruist.

This *redirection* of the drive to care for offspring is not rare. A couple may dedicate their lives to charity while choosing not to have a family. For some teachers, their school children act as substitutes for having their own family. For the priest, all his flock are his children. In all cases such as these, people have redirected their help to non-related individuals while at the same time receiving a similar level of hormonal reward as if they had helped their own children. The memes that drive this redirection, struggle for their own survival and not for the genetic benefit of the person whose mind they occupy. For the charity worker and the teacher, this redirection might only have been possible because of the existence of love-your-neighbour memes.

Also, due to the longevity of people today, some couples are only middle age when their children leave. In order to continue the level of hormonal release that a couple may have become used to when caring for their offspring, they may redirect their care to unrelated people, or even to pet animals.

Other memes may also parasitise this genetic drive by redirecting it. Certain memes such as 'protect your country' and 'it is glorious to die for your country', have combined to the extent that some soldiers *volunteer* to fight. The idea of 'kin' is expanded to include the whole country. Not all soldiers will have kin to protect. If a soldier has no kin then his/her fighting is an altruistic act. Even is there is some kin, the risk to the soldier's life might be disproportionate to the risk faced by those kin, and so there is a component of altruism here too.

In the Spanish civil war there were many volunteers from foreign countries who chose to fight fascism on principle. These volunteers had no kin in Spain. Their actions were altruistic to those Spanish also fighting against fascism. A number of reasons might have contributed to their fighting. Volunteers may wish to prevent fascism spilling over into their own particular country and so threatening their kin. Not all altruism results from a desire to protect kin. A second or contributing drive, might be that for adventure. To many it is exciting to travel and fight (nothing ventured, nothing gained!). Genetic drives for hunting might also contribute to this adventure and so indirectly to altruism.

The genetic drive to socialise may also lead to altruism. A prisoner of war may refuse to divulge the names of his compatriots (who are not kin) and suffer death as a result. His actions are altruistic from their eye-view. The strong bonds of socialisation have joined the soldiers together. Religions, habits or codes of honour may also bind groups together. A British regiment may fight to the death in order to be 'true to the colours'

or a sea captain may go down with his ship, while making sure that all the occupants, particularly women and children, get safely away.

The point made in this section on altruism is that memes can be successful in a mind if they maximise happiness (through hormonal releases), not reproductive success. As emphasised above, happiness and genetic success went hand and hand in our cave days. But today, sometimes this happiness is at the expense of gene multiplication due to the success of parasitic memes. On the whole this is a good thing. It is much better to have as your friends, people parasitised by altruistic memes such as 'love your neighbour', or socialisation memes such as 'support your comrades'. Your life will be happier in the company of these friends. They will enjoy helping you for the *sake* of giving help, not for any reason of duty.

There are also benefits for the environment from some of these types of parasitic memes. By limiting family size, contraception memes will control population size and so environmental impact.

Memes can invade the mind and cause actions that are detrimental in the eye-view of the genes. Kin and reciprocal altruism are not altruism in the strict sense of an act beneficial to another and detrimental in the eye-view of the genes of the altruist. Truly altruistic acts can, however, occur because the genetic reward no longer need align with genetic success. People can obtain greater happiness in some circumstances by acting altruistically.

4.10 Laws

Society's rules go under names such as *maxims*, *morals* and *laws*. Maxims could be 'a stitch in time saves nine' which increases efficiency, or 'more the merrier' which encourages socialisation. Morals are generally stronger than maxims. The meme 'love your neighbour' could be called a

moral. It is a part of the doctrine of most religions (although some do not extend 'neighbour' to members of other faiths). People who go against the morals of the day are often shunned by others. Laws are stronger than this again, breaking them usually involves physical reprisals.

Consider the following rule where the fidelity of sexual union is temporarily absolved:

> It was now the end of February, a period in the native calendar which is celebrated by a sort of carnival. Among the Sabas [a race of Chad] this feast has a special character and is known as the feast of the snake. The women prepare haricots with honey and butter, and at five o'clock in the evening everybody gathers in front of the Chief's hut. At a given signal all the men bring out whips and start attacking one another. They often draw blood but nobody cares on such a day. At nightfall this singular sport comes to an end, and they stuff themselves with haricots, empty a few dozen jars of millet beer, and dance till daybreak. On such nights there is a kind of "husband's truce", and the bachelors enjoy themselves. Any man, in fact, may enter the hut of any woman and stay with her, so long as she is willing. Nobody says anything, least of all the husband, who is probably lying outside himself, dead-drunk (Lapie 1943:91).

Here then is a cultural rule that is in competition with the genetic drive for men to ensure the fidelity of their wives. It is a type of robbing in that a husband or wife's sole sexual rights to his/her partner has been taken by others. For this rule to *invade* a population from an original mind, it must struggle successfully in various minds, aligning with some genetic and cultural knowledge and being against other knowledge.

How could this rule for allowing ritual infidelity succeed in a population? The rule at first appears to be detrimental to the genes: it would conflict with a man's genetic drive to raise his own children. There is a risk that children being raised may not be one's own. Yet this rule would be supported by those most strong, vocal and virile males. It might give them the chance to father a number of extra children; a drive of libido. It might also allow them greater pleasure (contraceptives not being available).

This infidelity rule is similar to the meme 'a sacrifice (or fast) is necessary to the god of iron' which benefited a priest class earlier. Here the virile are the 'priest class' and the rule allows their sexual diversification. Over time this rule may become a habit, the origin of which may be forgotten. People would know only that it is 'custom'. The same sexual drives no doubt led to the widespread polygyny in past civilisations.

The rule 'do not rob' if broken and detected, usually results in physical reprisals. If no one robbed the population would be more productive. Police would not be necessary and the work of the reformed robbers would now contribute to the society. However this utopia would not last. As there are no police, robberies would go undetected. Memes for robbing would easily invade minds, particularly the minds of men. Here the memes will get help in their struggle from the genetic drives for hunting and aggression. This drive is considerably stronger in men than women (very few women rob banks or take hunting as a sport). A man 'stalks' a bank and 'captures' the money which is used to nourish himself and the family unit. The genetic hunting action has been redirected at an institution.

The memes that act against robbing are laws in that they punish transgressors. They exist in association in both people's minds and in various books. A robber, if caught, must struggle to overcome the laws

of the day, rather than any particular individual (except those giving evidence). Imprisonment might result from laws made earlier by others. These laws are custom and maybe difficult to remove. In this way the 'law of the jungle' where only the strong survive can be modified to approach what we call today 'a civilised community'.

A new law is cast upon a sea of other memes. It may mutate (vary in its content) through its interaction with these other memes and so survive in a modified form or else it may fail in its interaction and go to extinction.

Laws and morals will usually increase the overall likelihood of the survival of an individual. Individuals support these rules because a net gain is perceived from them. The result is a co-operation between many, just as the reciprocal altruism in the previous chapter was from the co-operation of two people. A law is a community reciprocal altruism where transgressors are censured to ensure their co-operation in the future. While there is a loss from maintaining a police force, there is a net gain from greater safety. In a society where everyone has a say in making the laws, those laws will result in a greater benefit for all (except possibly transgressors).

But, like the rule for sexual infidelity discussed earlier, not all individuals need have a say in the making of laws. Many repressive regimes have laws that enforce actions that result in a benefit, but this benefit is only experienced by a few; an elite group. The memes of the law enter into a mutualistic relationship with other memes and genes of the elite but can be parasitic on the rest of the population. This will occur if the extra burden from these laws reduces the number, health, or happiness of the average person.

The extraction of taxes by feudal lords allowed them to maintain a grand lifestyle. An increase of the physical work load (growing food, building,

cartage, and so on) of the remainder was necessary. The lord was able (often with the support of soldiers) to enforce his memes into the minds of people. A law that allows him a certain percentage of that grown is given because the punishment is worse than the loss of some produce. The soldiers also receive a benefit, usually greater than the farmer, although naturally not as large as that of the lord.

Laws made by political parties often have the objective of solidifying their grip over a country. This may involve the repression of minority groups. Some countries today make laws that effectively allow only one party in an 'election'. Another method is to reduce the chance of opposition parties by not allowing them an outlet of advertisement; the television and radio remaining exclusively the organs of the reigning government. Once again, these elite political groups are supported by the same mechanism as the priest class described earlier. The sacrifice or fast to the 'god of iron' enhanced the priest's status, and the laws made by politicians are often to enhance their power and status as well as ensure re-election.

If a country is an oligarchy, where a small number of elite families own nearly all the property, and where the military enforces the decisions of these families, the laws made will be such as to continue the existing inequality of wealth and power. The memes for such laws will be successful in their struggle in the minds of the elite because they produce a benefit to them (increased happiness). In order for many of these laws to be successful, the general public cannot be allowed to contribute to their making as the memes for many of these laws would not, of course, survive in their minds.

A king or dictator has the ability to destroy a population by laws that produce a benefit to his mind only. A notable example was Stalin where use of fear of detriment was extensive. Normally, before a law is

established, its memes must survive in a number of minds before acceptance. The memes within a king or dictator's mind do not have to struggle for survival with memes from other minds; they need only struggle with memes and genes in the one mind. Not all solitary rulers are despotic, but the lack of meme competition makes this possibility considerably greater.

It has often been said that the reason for laws is to "protect the rich from the poor". There is some truth in this. A panel of law makers will enact laws, the memes for which are the outcome of the struggle of genes and memes of their minds. This struggle takes place through a 'discussion'. Rather than memes competing in one mind for prominence, they compete in a number of minds through the medium of conversation. As the law makers are often those of greatest wealth and/or influence, the laws they enact will generally align with their interests.

The English legal system is an adversarial one. In the days of knights each opposing side engaged a champion and the winner of the duel won the argument. A similar system existed between 'gentlemen' who were in disagreement. Their argument was settled by their ability to fence or shoot. This is only a slight progression from cave days when the strongest ruled. The British court system acts in spirit in the same way. Two opposing sides hire legal representation and then duel with legal argument. The object of this battle is to win, not establish the truth behind the disagreement. Either side may know of certain facts that would enlighten the jury as to the truth of the matter, but if they fear that such a revelation will decrease their chance of winning, they will try and prevent these facts from coming to light. However, as the jury relies for its decision on knowing the truth, the whole process can only be considered as corrupt. To add to this problem, as lawyers themselves make enormous sums of money from the lengthy debates necessary in this adversarial system, and as they often regulate change to that system,

change is slow to come. In other words, many laws, including those mechanisms of government, are made by elites, and as these elites still dominate the governments and legal system of many countries, change is improbable.

It is a sad fact that within an average person's lifetime, s/he will not have contributed to the making of a single law of the thousands that s/he will have to obey (although the government of a democracy will attempt to appease her/him by suggesting that a contribution has been made through voting for a particular candidate). One can see the problem for anyone bent on reform. A person might believe in the preservation of a forest and wish to pass laws to protect it. A person who fights for reform fights for new laws. The memes of these new laws must replace existing laws often made by people long dead as well as memes in the minds of living law makers. Others may believe in their right of continued work and so may want to use the timber of that forest. They will fight against laws protecting the forest. There is a struggle between the new laws of the reformer and the existing laws. This type of 'environmental' verses 'economic' struggle is that area of greatest legal struggle today.

Finally, a law may become 'spiteful' even though it was originally intended to be beneficial. A person may avoid punishment through exploiting a technicality such as a moribund law which resulted in an increase in the benefit to a community at some earlier time. Examples of spiteful laws would include tax 'loopholes' through which tax can be avoided even though such avoidance was never intended. The law is spiteful to the remainder of the population who must make up the shortfall.

A law is a community reciprocal altruism where the majority, through agreement upon a rule, can censure the action of a person that transgresses the

rule. Where the law is a rule of the elite, the law will censure those that transgress against these elite.

4.11 Religion

4.11.1 The Evolution of Religion

So far I have argued that new ideas are most successful in their struggle if they align with genetic knowledge that already exists within the brain. Some genetic knowledge already mentioned is that for curiosity, fear, hunger, hunting, and caring for offspring. A belief system, such as a religion, consists of memes in association and most of these can also be expected to align with existing genetic knowledge.

Genetic knowledge not so far mentioned is that for the euphoric state reached by meditation. A person can achieve this state through chanting or repetitive movements. Many zoo mammals confined to a small cage often pace up and down their cage. They quickly discover that repetitive movements produces a euphoric state which relieves boredom (Bergland 1985). It is unlikely that they would do this naturally in the wild, where their time is fully taken in finding food, shelter and mates. The evolutionary reasons for the development of this state are not clear - it may have had some use in an ancestral environment. Whatever the reason, it is a genetic property that mammals have inherited (showing our common origins).

The meditation of religions aligns with this genetic knowledge. A person going into a church is likely to listen to a sermon which may be followed by hymns. The sermon is the expression of memes that reach prominence in the priest's mind. By exposure to the congregation, some of these memes may colonise their minds. This colonisation is helped or reinforced through the chanting of hymns and songs, by which people

often reach meditative states of varying strengths. The feeling of tranquillity so induced, that is, the change effected in the mind, may make it more susceptible to colonisation by memes. The elated feeling may be attributed to the 'presence of God' and so be used as support for the truth of the sermon. The religious dogma uses the happiness gained from meditation as an entry to the mind.

Another genetic property used by religions is fear. Fear of the unknown is a universal property of all mammals and reins in the desire for exploration driven by curiosity. Mammals show caution when exploring new environments. A knowledge of the environment is advantageous, yet this environment must not be explored too recklessly otherwise an injury may result. Most religions require an unwavering belief in dogma, not a questioning of that dogma. Dogma not to be questioned could be referred to as the religion's faiths. Religions must prevent members investigating too thoroughly their faiths, that is, they must limit curiosity. Memes that align with fear are often used to achieve this. This may be a fear of a degraded life after death (hell), fear of excommunication, fear of community rejection, or fear of the wrath of god. In contrast, by adopting the memes of the endemic religion, a person may escape fear. They come under the protective wing of the religion, with loyalty and faith the only reciprocal price required of them. Problems can be referred to the priest where absolution of wrong doing through confession may be possible.

Other memes might have success by mixing dogma with genetic 'truth'. For example, the sentence: 'You want happiness, don't you?, through god you can find happiness', could be part of any sermon. The first part of this sentence is true in that we all seek happiness from hormonal release in the brain. It is a *genetic* truth. The second part is dogma, it is a cultural idea. For many, the existence of a god is far from certain. The first part of the sentence, 'you want happiness', easily invades the mind,

and in so doing drags along its attachment. Meme multiplication is about survival, not truth. The meme 'there is a god' will survive or fail depending on the success of its struggle in the mind. The idea of god, by its association with happiness, is being wrapped in a genetic truth for its passage into the mind.

But a person might actually live a happier more useful life by believing in a god. While there may be little evidence for certain dogma of religions, it does not mean that this dogma fails to work. Many religious memes, such as 'love your neighbour', contribute considerably to the overall happiness of a population. A person gets the same genetic reward as if s/he had assisted offspring, by redirecting this help to unrelated people. The meme 'love your neighbour' is not a *genetic* truth, in the sense that it does not promote the multiplication of the genes. It is not 'true' or 'good' in the eye-views of the genes. However it is 'true' in the sense of increasing happiness.

Religious memes may also align with our genetic drive to socialise. A sermon might be followed by shaking hands with neighbours or hugging them. Each may tell the other a little about his/herself. All this promotes socialisation and reduces loneliness. A person feels part of a social group and this feeling of well-being, like the meditation, may change his/her mind and so allow religious memes greater chance of survival. Cultural knowledge for socialising easily enters the mind as it aligns with genetic knowledge for socialising in its struggle. As these memes for socialisation enter, they may take in various dogma associated with them.

Genetic drives are so central to the success of memes that people can obtain special status in the eyes of the community by denying them. A priest may claim special status or a religious person may demonstrate devotion through celibacy, fasting, arduous pilgrimages or other self-

denial. People stand in awe of a person in whose mind memes in opposition to one of the main genetic drives have been successful in their struggle. That this is an uncommon event emphasises the success of the genetic drives in influencing the nature of the cultural knowledge in the mind.

Special status can also come by the possession of exclusive knowledge. In Africa, an energetic sinuous dance punctuated with incantations often precedes a witch doctor's divinations. These acts promote awe, fear and admiration in the common people, lest the strong cultural knowledge of these individuals be redirected to their demise.

Categorisations of broad and narrow niches can be made with many belief systems, particularly religions. A fanatical religion intolerant of dissent would have a narrow niche. Members' beliefs are consistent and within a narrow range. The faiths that form the basis of the religion are tightly knit, rarely allowing new memes to invade. New memes are vigorously repressed. If this cannot be achieved through reason, fear, or threats, then the physical body that holds the new memes must be expelled or eliminated. Similarly, in cults the activities of members are often highly constrained. Commitment is total and all socialisation occurs with the group.

The Jehovah's Witnesses consist of tight knit communities that discourage outside contact. A member who denies any of the fundamental faiths (that is, a particular dogma fails in its struggle in the member's mind), is often cut off from further contact from the whole community. As the member's friends and family are concentrated among the church members, this act of rejection disallows the socialisation drive expression. The rejected member has no one to turn to as a temporary social group to obtain the hormonal reward for socialising. The strength of this drive forces many back into the fold.

Some religions have inherited a narrow dogma. These religions rely heavily on historic documents such as the Bible and the Koran which gives them an inherent inflexibility. Their literal messages are limited in their interpretation.

Religions with broad niches could be those which tolerate a wide range of beliefs. These would include the Quaker, Buddhist, and Baha'i religions.

The number of religions that exist today represent only a fraction of those that have gone before. Extinctions can result from physical or cultural causes or combinations of these. Physical catastrophes, such as volcanic eruptions, earthquakes, floods, disease, or famine, can all cause the demise of a population and so its endemic religion. Invasion may result in the religion of the conquerors being adopted. Or a new religion may evolve that is a combination of both religions. Many of the religions of South America have combined both Christian and aboriginal beliefs, while many aboriginal African religions are either extinct, or in decline.

As stated at the beginning of this chapter, the memes of a belief system will, to a large extent, align with existing genetic knowledge already in the mind. All humans contain the same fundamental genetic drives, regardless of where they live in the world, although the strength of these drives (or talents) may vary slightly depending on the local environment endured. As the memes of religions evolve in the context of these genetic drives, we can expect the world's religions to have the same *general* beliefs, but vary in their *particular* beliefs depending on the local environment. Nearly all religions have a god or gods, some explanation for how the world started and what happens after death, various rules to advance social adhesion among its members, the use of fear and rewards to channel people's actions, and a priest class that benefits to varying

extents from these channelled actions. The priests are the guardians of religious knowledge and may moderate it from time to time.

For an example of general and particular beliefs: some Polynesian seafaring people have the spirits of their ancestors inhabiting sharks while some land locked African tribes have their ancestral spirits inhabiting hyenas. Both have the idea of spirits and both will fear not following custom in regard to these animals. The belief in spirits is a general belief, while that these spirits inhabit sharks or hyenas are particular beliefs. Campbell (1991) gives numerous examples of parallel evolution in respect to similar beliefs becoming established in populations independent both in time and place.

4.11.2 The Coevolution of Genetic and Cultural Religious Knowledge

So far I have argued that memes which align with the genetic knowledge of the mind improve their chance of success when struggling in it. But can this work the other way around? *Would new genetic knowledge in an offspring that aligned with the memes of the endemic religion increase the offspring's chance of survival*?

Offspring vary in their genetic knowledge. They may have a genetic talent for mathematics or music. Equally, an offspring might be born with a genetic talent for accommodating aspects of the endemic religion. As offspring survive differentially in their environments, and as the religion is part of this environment, then having a religious talent might increase the chance of survival. If so, then the genetic knowledge for this religious talent will spread to successive generations.

Having a genetic talent for religion does not mean that individual doctrine is encoded genetically. There is not a god gene, for example. Rather, the genetic talent is a genetic drive to participate and believe in

religion, a sense of spiritual feeling; just as a musical talent will incline a person to listen to and play music if given the opportunity; or a mathematical talent will drive an interest in numbers. We know genetically that by drinking water our thirst will be quenched. We have a genetic knowledge of water. Similarly, we may know *genetically* that there is a god or spirit, something extra than only physical beings.

If so, genes for a belief in god, or genes that allow this belief easier entry into the mind, should spread throughout the population. Over time aspects of religion should become entrenched genetically.

There are a number of basic problems with this argument. Firstly, how can being religious possibly affect reproduction? History provides many examples of people who refused to accept the religion of the day and suffered death or discrimination. If resistance to the memes of the religion is from genetic knowledge, then any subsequent repression would limit the spread of this genetic knowledge. This would be just the same as if a person was born with faulty genes that affected eyesight (say). The poor eyesight would diminish the chance of survival and, sooner or later in a succession of offspring, these genes will be lost. Offspring with genetic knowledge that resists the entry of religious memes will have a diminished chance of survival. Conversely, offspring with genetic knowledge that favours the entry of religious memes will have an increased chance of survival. In the long term, only offspring with a religious *talent* will be left.

This leads to the second problem. While some offspring without religious talent might die out, have religions been part of our environment long enough for there to be any significant genetic change? *Homo sapiens* have been recorded for at least half a million years with evidence of elaborate ritual burials (presumably the result of religion) some sixty thousand years ago (Leakey 1994). Sixty thousand is twelve

percent of half a million. For the sake of argument, let us accept that religions have existed for this time. If a generation length is taken as fifteen years, four thousand generations have occurred since the beginning of ritual burial. Is this sufficient time for any religious talent to develop?

How fast evolution occurs is dependent on such things as the extent of environmental change suffered, the mutation rate, and the generation length. As we saw earlier, the insects sprayed with poison in agriculture experienced a rapid environmental change. This environmental change, as well as their often short life cycle, resulted in rapid evolution. But no new genetic knowledge was necessary to start this process. There was usually sufficient neutral knowledge latent in the population to accommodate this environmental change. Some insects knew of the poisoned environment without themselves or their ancestors ever having experienced it. Further, new knowledge in successive offspring will add to and modify this now beneficial knowledge. A talent for resisting the poison has developed in just a few generations.

Should a new religion arise, the environmental change will not be anywhere near as great as the poisoned spray. There may well be neutral genetic knowledge, now beneficial, that will spread through successive offspring. Initially, no new mutations may be needed. New genetic knowledge in successive offspring will supplement this neutral knowledge as religious talent evolves. If a few generations are sufficient for the insects, four thousand generations should be sufficient for humans to generate at least some religious talent.

The strength of a religion's prejudice against dissenters will vary for different populations in different parts of the world. It will affect the rate of evolution of knowledge, and so religious talent, like other talents, will vary in strength among individuals. Of course, should those with the

greatest religious talent become celibate priests, then this talent will suffer in its rate of spread. But as the number of priests is not that great, and while this 'culling rate' will slow growth, growth in religious talent should still be sustainable.

Religion, once a cultural idea, has become in part fixed genetically. There has been a movement of cultural knowledge to genetic knowledge. This movement is to be expected. Just as there is a coevolution between genetic knowledge and the physical environment, we can expect none other than a coevolution between genetic and cultural knowledge.

Today, one of the most prominent belief systems is science and this has encroached on religious beliefs to varying extents. Belief in god has diminished among scientists. But a genetic talent for religion may still exist as change to the genetic system is at a slower pace than cultural knowledge. Any remnant genetic knowledge in people who no longer believe in religion, is to them a 'genetic myth' (the idea of myth is the subject of section 5.2). It is this genetic remnant that drives the scientist's inner feeling of spirituality, with this feeling stronger in some than others depending on the degree of latent genetic religious talent. This genetic myth might predispose an atheist to again adopt religion; invasion of religious memes would be made easier by alignment with this genetic remnant.

Another possibility is that scientists could redirect this religious drive towards their chosen discipline, with the leaders in this discipline becoming the priests of their new religion. By so doing they gain fulfilment from the expression of their genetic religious drive.

4.11.3 God and the Big Bang

Evolution gives a good account of the emergence of life *given* the existence of the Earth. But it says nothing about its origin. This brings us to a fundamental question: what is the origin of matter? If we can explain this, evolution will explain the rest.

The idea of a *big bang*, where matter, space and time were simultaneously created, is widely held among scientists. For religious people, the world was created by a god. Will these two ideas always be in opposition or can they be reconciled?

As there is some 5 billion years left on Earth, there might be a number of new knowledge systems yet to evolve. Let us say that in some future time entities of one of these new knowledge systems have an intelligence somewhat greater than humans. Human knowledge is not trivial - the nuclear explosion and our travels in space are great scientific achievements. This greater intelligence could also be expected to achieve scientific milestones. The initiating of big bangs might be one of them. If so, then the initiator of this big bang would be god to any future life forms that evolved in the newly created world.

This is of course, sheer speculation, but it demonstrates that evolution and god are not necessarily separate ideas. If the above were true, then god would have evolved. Unfortunately, if god evolved, then matter must have preceded his/her evolution, and we are again left with the problem of the *cause* of the first big bang.

Religions are belief systems that contain memes in association. These memes are mutualistic with other memes of the religion but may be mutualistic or parasitic in respect to other memes and genes. It is possible that some religious cultural knowledge has become genetic knowledge.

4.12 Summary

The brain evolved as an organ that allowed genetic knowledge variable expression within the life of the organism. Simple organisms could use their senses to respond differentially to incoming environmental information. Yet new knowledge, that is, a new way of responding, could only be gained by offspring. Knowledge change was still linked to the generation length. The next stage in brain development was to store knowledge gained through experiences of the environment. Events could be remembered and this knowledge could be used to generate different actions under the same circumstances. Animals had still to learn all their knowledge within their lifetime. This remembered knowledge was the first cultural knowledge. A further stage was the passing of knowledge intentionally from one organism to another, particularly in a period of nurturing. These passed units of knowledge were the first memes. The development of the brain was most pronounced amongst generalists. This cultural knowledge became progressively more ordered and complex. Abstract thought became possible. Here memes within a mind generated other memes. The meme is an independent form of life that has come from a mind that originally contained only genetic knowledge (innate knowledge) and ideas. A new idea struggles for survival with other memes and genetic knowledge resident within the mind. Both memes and genes undergo multiplication and differential survival. This single process of evolution is the *only* process that separates life from non-life.

Memes, in the form of laws, can invade a society if that law increases the average payoff of persons influential in the law making. These memes are mutualistic in their eye-views. Any such meme may be parasitic in the eye-view of others. A religion is a belief system that contains memes in association. Various memes of a religion may be mutualistic or parasitic in respect to the genetic body. Memes and genes can manifest

themselves physically as artifacts. The complexity of these artifacts is such that some (computers) have developed "environments" of their own which have given rise to new units of life; remes. Life consists of a series of levels or environments, each in turn invaded by new life forms.

5. Applications

5.1 Introduction

In the last chapter I argued for the meme as a unit of evolution that is copied from mind to mind. I will now attempt to use this concept, and other ideas developed, such as the coevolution of cultural and genetic knowledge, and the parasitism and symbiosis of memes from the eye-view of the genetic body, and apply these to some of today's problems, in particular, environmental problems. I will first deal with the idea of myth which overlaps with earlier explanations of altruism in that the origin of some knowledge, both genetic and cultural, can be lost yet this knowledge is still active in driving particular actions. This idea of myth will be a theme that runs through later sections. I will then consider the coevolution of cultural and genetic knowledge in medicine, the separation of humans and the other animals in belief systems, the economics of fossil fuel use, materialism as a belief system analogous to religion, and finally, to take a different direction, evolution in literature. While these topics represent a cross section of the evolution of knowledge other examples could have been chosen. This chapter is not meant to be in any way conclusive, it is simply a series of sketches to introduce the practical application of the ideas developed earlier.

5.2 Myth

5.2.1 Myth in Science and Religion

The Oxford Dictionary gives a myth as 'a primitive tale imaginatively describing or accounting for natural phenomena'. It is a 'fictitious or unproven person or thing'.

Joseph Campbell's perception of myth could not include science:

> From the point of view of any orthodoxy, myth might be simply defined as "other people's religions", to which an equivalent definition of religion would be "misunderstood mythology", the misunderstanding consisting in the interpretation of mythic metaphors as reference to hard fact: the Virgin Birth, for example, as a biological anomaly ... What in the name of Reason or Truth, is a modern mind to make of such evident nonsense? Like dreams, myths are productions of the human imagination. Their images, consequently, though derived from the material world and its supposed history, are, like dreams, revelations of the deepest hopes, desires and fears, potentialities and conflicts, of the human will - which in turn is moved by the energies of the organs of the body operating variously against each other and in concert. Every myth, that is to say, whether or not by intention, is *psychologically* symbolic. Its narratives and images are to be read, therefore, not literally, but as metaphors (1988:55).

Campbell suggests that myths are "productions" of the human mind, that is, memes are mutations from the current stock of knowledge within the mind.

Myths are common in religions and folk medicine. The idea of a subterranean hell or the use of spells to drive out disease are myths. Religion and folk medicine also contain truths. A religion which teaches that happiness can come through 'loving your neighbour', teaches something true. Many herbal medicines do effect a cure, it is true that they work. Belief systems contain true, false and unproven memes.

In contrast, science is often taken as a factual belief system. Science is 'the systematic study of the nature and behaviour of the material and physical universe, based on observation, experiment, and measurement, and the formulation of laws to describe these facts in general terms'. Science is testable in the field and so proven to some degree of error, while myth is unproven. Being unproven does not mean false, and many myths have later been shown as true. Equally, many scientific beliefs have later turned out to be false (such as Piltdown Man - see Sollas 1915) or only approximations when better equipment and/or experimental methods have been used. Other scientific beliefs have only occurred because of accidents in the laboratory (Richards *et al.* 1964:840).

Dawkins (1995) has argued strongly against the suggestion by some that science has a mythical element. In contrast, Raymond Williams gives a number of alternative ways myth has been perceived including that "myth has been held [by some people] to be a truer (deeper) version of reality than (secular) history of realistic description or scientific explanation" (1988:212). To some people their myths may be reality, but their exceptence of their beliefs has been far from critical. While many scientists realise that their beliefs are far from perfect, they see them as metaphoric in respect to some greater truth - approximations that will be improved by later generations of scientists.

To some Christians, Christ's virgin birth, death on the cross, resurrection, and the miracles he performed were all true events. For other Christians, taking the bible more of a historic document than the literal word of God, these events are unproven or even false. These beliefs would be myths according to the definition above, falling into the false or unproven category. But even in the broadest interpretation, where the virgin birth is not taken literally and that Christ did not die on the cross but recovered to re-emerge from his tomb, still leaves at least two

fundamental myths in Christianity: the existence of a God and life after death. Religious systems rest on a number of inviolable myths.

Are there any fundamental inviolable myths in science? The atom and its mechanism could be considered as fundamental to science. No doubt this belief has a mythical component, but it must be remembered that an artifact such as a television is founded in its construction on our current understanding of atoms. Televisions work so this understanding of atoms must have a component of truth. This is the difference between science and religion. Fundamental scientific myths have a proven component of truth (through experiment), while fundamental religious myths need not have.

5.2.2 The Origin of Myths

Earlier I suggested that a person might 'think up' an idea. New ideas are created from old ideas within the mind. What is this 'thinking up' process? The brain tries to construct meaning from the environmental information it receives via the senses. The incoming information is changed to cultural knowledge and in this process it is approximated by division into bounded regions. The way a mind does this division will depend on its existing genetic and cultural knowledge.

> In the early days, when white men first went into the far interior [of the Congo], the natives concluded that the boots they wore formed part of themselves, and it became a legend among them that white men had webbed feet (Ward 1910:208).

The image of the boot could not be separated from the body because the cultural knowledge of the natives did not cater for the foot being covered. Covered feet were not part of their understanding. Memes,

including words themselves, are bounded units of cultural knowledge. If these boundaries are incorrectly placed upon the environment, then myths can arise. The meme 'foot' in the minds of the natives was expanded to include the boot of the European. The incorrect interpretation of the boundaries of 'foot' led to the creation of a myth. The explorer did not have webbed feet, yet he had feet. The myth contained both false and true components.

The English geographer John Speke received the following information:

> [My agent] who went south from the N'yambara station, came amongst the N'yam N'yam, and heard from them that a large river, four days' journey more to the southward, was flowing from east to west, beyond which lived a tribe of 'women', who, when they wanted to marry, mingled with them in the stream and returned; and then, again, beyond this tribe of women there lived another tribe of women and dogs. Now, this may all seem a very strange story to those that do not know the negro's and Arab's modes of expression; but to me it at once came very natural, and according to my view, could be interpreted thus:- the river, running from east to west, according to the native mode of expressing direction, could be nothing but the Little Luta Nzige running the opposite way, according to fact and our mode of expression. The first tribe of women were doubtless the Wanyoro - called women by the naked tribes on this side because they wear bark coverings - an effeminate appendage, in the naked man's estimation; and the second tribe must have been in allusion to the dog keeping Waganda, who also would be considered women as they wear bark clothing (1863:474-475).

Speke was looking to re-interpret this report (from one of his native scouts and so constructed with the scout's framework of memes) within the boundaries of his own memes. This was necessary as his journal was to be read by others with the same meme boundaries as his own mind and so reports had to be made comprehensible to them. Any misinterpreted boundaries that are taken as true boundaries by the reading public in England would represent myths about Africa.

As a generalisation, the smaller the intersection of meme boundaries between populations the more likely that myths will be created through misinterpretation.

A similar case can be made for science. The smaller the intersection between a cultural knowledge of the natural environment and the reality of that natural environment the greater the likelihood of scientific myths. The alchemist had a lesser understanding of chemistry than a contemporary chemist. His belief that gold could be made from lead from ordinary chemical reactions was a myth of the time. There was a large difference between his knowledge of the natural environment, and the reality of that natural environment.

Sometimes the desire to break the environment up in to bounded regions is so strong, that 'order' is found where none really exists. The African witch doctor might find meaning in the random patterns of sticks and stones or the flight of crows. The European might find them in cards, tea leaves or the stars. Such patterns have real meaning for these people. Like the misinterpretations above, this over interpretation also results in mythical cultural knowledge.

While a cultural belief may be mythical, its origin may be lost:

> I have to-day been surprised and delighted by a rare visit; three dwarfs came to me, and, although they were rather shy and distrustful, I managed to reassure them to some extent. I made the interesting discovery that soldiers from Momfu have no difficulty in chatting with these pigmies, their language being apparently identical. My visitors were of fair complexion, bearded, taller than the dwarfs I had previously seen in Monbuttu, and particularly ugly. Except for a small loin-cloth, they were completely naked, and they trembled with excitement and fear; throughout our conservation they held some magic roots firmly in their hands for protection. They received presents and promised to return to-morrow. I mention this because the dwarfs are so shy that they have never before come to any European (Emin Pasha, in G. Schweitzer, vol. 2, 1898:249).

Here the roots, as protection, have such currency within the minds of the pigmies that they were prepared to risk their lives. It is quite likely that this belief in the magic power of the roots is custom and of long standing, with the origin being either obscure or lost. The pigmies would have had numerous beliefs, with many of these confirmed through practical experience. A belief that the meat of a certain animal is good to eat would be periodically confirmed. Even those who had not tasted such meat would not doubt its goodness given the anecdotal evidence presented to them by others. For a person who had not tasted the meat, that it is good to eat would not be mythical in his/her eye-view. Yet the expectation of protection from the roots would have to be called mythical - even if their protective value is occasionally 'experienced' through coincidence or through a reciprocal belief in their protection by neighbouring tribes. The pigmies' safe return from their visit to the explorer would be considered as proof of the effect of the roots just as the consumption of meat would be considered as proof of its taste. But the

roots are not like the 'white flag' of truce. This flag is simply symbolic of an agreement and it is the agreement about this symbol that protects the person not the flag. For the pygmies, it is the magical roots themselves that give protection.

Belief systems contain numerous memes which can be mutualistic or parasitic in their relationship with genes. A religion is a belief system that contains a high proportion of faith beliefs which cannot be verified in an external environment while a science contains a low proportion of faith beliefs with most memes verifiable in some external environment. Environmental information can be turned into myth if boundaries are incorrectly placed upon it. The myth may become a habit and with its origin being lost.

5.3 Medicine

I will consider in detail here the evolution of scientific and folk medical knowledge. This example will combine ideas on the coevolution of genetic and cultural knowledge (section 4.3) and also emphasise the role of parasitic memes, memes that often form the fictional component of myths. The choice of "medicine" here is coincidental. Other fields, such as the development of housing, the manufacturing industry, the change in our modes of transport, fishing techniques, geological practices and so on, could all be argued in the same way. All are fields that have evolved and are characterised, like human behaviour in general, by a shift of control from being originally dominated by genetic knowledge to control by cultural knowledge.

During our cave days, before folk or scientific medicine, the human body relied on defences derived from genetic knowledge to correct mishaps and conquer diseases. Bones mended themselves, cuts healed, and infections were fought with antibodies and phagocytes. Since then there has been a progressive transferral (or addition) of cultural knowledge to

assist or subsume this genetic knowledge. The antibodies of the blood can be assisted with antibiotics such as penicillin. Cuts can be cleaned with disinfectants and bones can be set in casts. This additional knowledge is not genetic; rather it is cultural, knowledge that is passed from generation to generation not via the germ cell but through the senses.

From where have these memes come? There appear to be two distinct paths. The first is traditional or folk medicine, which has an origin intertwined with various myths, the origins of which are often obscure. A particular cure may have originated something like this: a person(s) within a society may notice a herb aid with the cure of some illness, later someone may cook it, thereby causing a greater effect, while still later it is mixed with other herbs and so on, often taking hundreds of years to evolve to the current recipe. This knowledge has come about through an accumulation of chance events being noticed and retained. A person may accidentally eat a plant while thinking it was a different edible plant. If this plant has a certain effect that is deemed useful, it may be retained by a community and so knowledge of this plant enters the system of inherited cultural knowledge. These chance events - or mutations - represent an injection of new cultural knowledge to the community. The stimulus for new knowledge here is external, that is, memes are generated by environmental information. This was emphasised as the usual method of new memes before pretrialing (see section 4.2).

A second path for new cultural knowledge is through scientific experimentation. This can also contain a random element. Formulae are not all derived mathematically from known natural laws. In the last section I gave the example of randomness leading to new scientific knowledge. This is equivalent to the chance noticing of a herbal mixture being of benefit for some ailment and the passing of this knowledge to others. The object of traditional medicine was not to find a biological or

chemical reason as to why the herbal mixture works. Rather, it was to find cures that did work and could be passed to offspring. Herbal cures evolved from the differential retention of environmental information with this retention driven by the desire to live and avoid pain.

Medical knowledge also has been gained by scientific processes. Here a scientist, through his acquired knowledge, proposes a possible cure through mental thought (pretrialing) and this theory is then tested experimentally. There will be a random input to the creation of these new memes as well as in the testing of this theory. New memes arise within the mind that are tested for suitability in their mental environments, and if they survive, they are further tested in the physical environment. The difference between scientific and folk medicine is that new knowledge for folk medicine comes mostly from events in the physical environment (environmentally led) while new knowledge for scientific medicine comes mainly from events in the mental environment (through pretrialing which is culturalally led). Because scientific knowledge is from the mind, it may evolve at a faster rate. Some scientists cannot separate the origin of the knowledge from its value, and so have given little credit to traditional medicine. This is unfortunate. Both forms of knowledge may be just as valuable. Not surprisingly, cures from both origins often have active ingredients that are the same or at least from the same family of chemicals.

It must be remembered that humans are not all the same and different traditional medicines will apply to different people. The diet of meats of Eskimos and the diet of blood, milk and meat of the Masai are a selection pressure for the development of specific physiological adaptations for a diet rich in protein and fat (Alekseev 1992). The particular folk cures of these people will no doubt emphasise some of these characteristics. Cures may be to counter the excesses of these diets and are not necessarily applicable to other cultures.

Both scientific and folk medical knowledge systems have suffered, and are still suffering, from negation by or inclusion into religious belief systems. Many traditional cures were linked with practices that were not necessarily beneficial, or as beneficial as they could have been to humans. The practices may have been interwoven with various ideologies serving the needs of these belief systems as well as for medical use. For example, blood was let from an infected arm not realising that blood actually circulated throughout the body. Similarly, medical science has had, and is still having, spectacular failures due also to interference by commercial interests. For example, asbestos dangers were hidden by biased medical reports, the contents of which were influenced by mining companies bent on retaining production levels and so ensuring continuing profit. Some operations are performed today more for the financial health of doctors than for the physical health of the patient. The removal of the tonsils or appendix to *prevent* a possible a future infection was medical opportunism on the part of doctors. Some religions negate the use of scientific knowledge by prohibiting practices such as blood transfusions. However, putting these examples aside, there is still a core of scientific medical knowledge that has had great success in raising human health, thereby increasing life quality and longevity. But, as I will now argue, this increase in health comes at a price.

Genetic and cultural knowledge have each other as part of their environments and so coevolve. Each compete with the other for that knowledge. The greater worth of the knowledge of a meme of gene, the greater its chances of survival. For example, say there exists a disease "A" which, if contracted, kills those members of the population with no genetic resistance to it. This disease is a selection pressure for the removal of individuals without the resistant gene. A medical cure for this disease removes this selection pressure. Individuals without this gene are now free to increase in number within the population. These people

are now resistant to A, not through a genetic knowledge of the disease, but through a cultural knowledge.

There are thousands of genetic errors of metabolism (see McKusick, 1990). In chronic grandulomatus disease, which is usually inherited as an X-linked recessive trait, the ability to fend off infection is reduced allowing recurrent bacterial and fungal infections. Other examples include genes that resist the polio virus while still others resist the toxins that are a by-product from the diphtheria bacillus. An individual is susceptible to these diseases should their genetic knowledge be insufficient. These infections could be our disease A that is a directional selection pressure for the retention of resistant genes.

From the eye-view of the genetic body, whether protection comes from within though genes or through the memes is not important. Survival and so reproduction is guaranteed as long as the knowledge remains in place. The long term effect of this selection pressure is a transferral of the body's knowledge for survival to a cultural knowledge for survival. As can be observed from the average length of survival of the modern human, such transferral to and addition of cultural knowledge is selectively advantageous to the genetic body. However, in exchange for this increase in health there is an accelerating use of medical services. The ratio of doctors (agents of medical knowledge) to members of the public has been steadily increasing and, in tandem, a steady increase in human resources consumed. Earlier I suggested that religious memes hitchhike their way into the mind by aligning themselves with natural properties of the body such as fear and the euphoria from meditation. Similarly, medical knowledge aligns itself with our genetic desire to live (and avoid death). But, whereas aspects of religious knowledge can be parasitic on the genetic body, cultural medical scientific knowledge is usually mutualistic, at least in the short term. The medical memes need not feign a mutualistic relationship with genes; rather the relationship is

truly mutualistic. In the long term, if most of our resources are spent on medical support of a genetically weakened population, the memes are parasitic on the genetic body. Indeed cultural memes have caused the extinction this genetic knowledge.

Other problems with medical knowledge include its concentration within the minds of a few. If a person is able to provide substantially his own cures, that person retains control of his body. Where the person has to rely on medical knowledge and physical manifestations of that knowledge (medical instruments) in order just to survive, then that person has handed over control of his body to an outside agent. For example, if a premature birth is caused through lack of certain genetic knowledge, and the child survives through the application of cultural knowledge, then this lack of genetic knowledge is perpetuated in the society. Similarly, a caesarean birth results in a selection pressure for smaller hip size. There is a loss of genetic knowledge to produce large hips. Control of health is being shifted from genetic to cultural knowledge. We are progressively becoming "slaves" to this body of knowledge. Our actions are becoming directed more and more by external knowledge. A proportion of society's resources will be consumed by it, and a proportion of people's actions directed by it. In some places it is actually illegal to have a home birth or a birth without medical supervision. Here a law has managed to invade minds enforcing the acceptance of cultural knowledge. Such a law may have been rigorously petitioned for by a medical committee and so represent more the interests of the medical body than the general public. Likewise, rules in hospitals are more for the benefit of the medical staff than patients. This is of course to be expected as the rules are the weighted beliefs of medical staff. It is a common lament amongst mothers that they were "de-humanised" during the birth process by hospital staff and their practices.

In some cultures, medical practices are controlled by political belief systems for the benefit of those systems. Persons who have alternative views are incarcerated in mental institutions. The "treatment" that follows often renders them genuinely imbalanced. If rules for the application of medical knowledge are restricted to medical staff (the "priests" of medicine) then greater control of the people and a greater application of medical knowledge at the expense of genetic medical knowledge can be expected. Also scientific medicine can (and is doing to some extent in western countries) repress folk medicine just as two species will struggle for dominance. Some countries, governed by religious laws, suppress scientific medicine as it is seen as a threat to religious power. Tibet was one of these.

> The policy of the government towards government is a dark chapter in modern Tibet. The doctors of the British and Chinese Legations were the only qualified medical personnel in a population of three and a half million. Doctors would find a rich field of activity in Tibet, but the Government would never allow foreigners to practice. The whole power was in the hands of the monks, who criticised even government officials when they called in the English doctor (Harrer 1955:137).

Tibet at this time had an autocratic government of monks. The monks who administered medical treatments had no knowledge of medicine as we know it, rather they relied on medieval practices such as chanting and the application of heated iron rods to the skin. The successful curing of patients by alternative methods such as western medicine, would have directly encroach on their authority. Their interest was political control rather than the well being of the people. Such corruption was endemic.

> There is no organised system of law courts in Tibet. The investigation of offences is entrusted to two or three persons of noble rank, but corruption is unfortunately very prevalent; in fact few nobles have a high reputation for integrity. The sums received as bribes are regarded by many as part of the prerequisites of the feudal system (Harrer 1955:196).

Unfortunately when the Chinese invaded, one corrupt regime was replaced by another even more corrupt. About one third of the population was killed, considerably more than any loss by poor medical practices. Logging and mining commenced without any concern for environmental degradation or the cultural practices of the Tibetans. To the Chinese, Tibet was a vacant niche to be exploited for its mineral and forest reserves, and for use for the relocation of a burgeoning Chinese population. The cultural repression by the Chinese of the Tibetans had an enormous deleterious effect on the health of the nation.

The health of many individuals is compromised by the cultural inability to override certain genetic knowledge. In our evolutionary history, body needs became encoded genetically in our system of taste. Sugars and fats were richest in energy and so humans were selected for a desire to obtain them. Salt was also necessary for our diet and its scarcity led, in some regions, for its use as money. Sugars, fats, and salt were in generally in short supply and so genetic knowledge driving their consumption through recognition by taste, was selectively advantageous. The consumption of these three basic foods was rewarded with happiness, that is, they tasted pleasant. Those humans whose taste buds were most sensitive to the detection of these components fared best. It was rare for ancestral humans to be in a situation where these foods were in abundance and so little genetic knowledge was devoted to a restriction of their consumption.

The use of fossil fuels has allowed us to produce these foods in abundance. If we go into a shop, those quick snacks available are all based on these three dominant ingredients. Potato chips are salt and fat, chocolates are sugar and fat while other sweets are just sugar. A significant number of people then die from the excessive eating of these foods. Because there is little overriding of genetic knowledge by cultural knowledge, there is currently a campaign to create and disseminate such cultural knowledge. Governments warn against overeating and the benefits of moderation. Even so, some people never manage to adequately control their genetic drives and so obesity is commonplace, particularly in western countries.

Medical memes align themselves with the genetic drive to survive in order to invade the mind. They enter into a mutualistic relationship with genes. Memes and genes compete for possession of this knowledge as possession is correlated with their survival. Unfortunately, the outcome of this process is an increasing reliance on external medical knowledge, and so an increasing proportion of our resources devoted to medicine.

5.4 The Separation of Humans and Nature

The various species of mammals show remarkable similarity in their skeletal design, internal organs, reproduction, and so on. A good proportion of the genetic knowledge is held in common across this class of vertebrates. Small genetic differences in humans, such as the voice box that allowed speech, have led to an explosion of cultural knowledge. The amount of cultural knowledge passed between humans is growing. In some countries, children may spend as much as twenty years studying before employment. The belief systems that have arisen with this cultural knowledge separate humans, by virtue of the volume of their knowledge, from the rest of the other animals. This separation is ensconced in our memes. For example, the use of "he" and "she" as

pronouns for humans and "it" for all other animals and objects make separation an element of language. The suggestion in Genesis that animals were made for the use of humans places animals at the resource level. The belief in some religions that only humans have souls and therefor an afterlife, is a religious separation of animals. The idea that *all* actions of animals are natural whereas those of humans can be both natural and unnatural (artificial) separate these actions from other animals. This separation is fairly recent, with many cultural groups existing that have been little influenced by western culture. They still see themselves as integrally part of nature. In contrast, new ecological belief systems such as 'Deep Ecology' have as one of their fundamental doctrines the interrelatedness of all life forms, with humans having no special status from the other animals (Fox 1990).

When Europeans came to Australia it was necessary to give the Aborigine the status of "savage". By doing so Aborigines could now be seen as another animal, not a fellow human to whom certain moral obligations (dictating standards of behaviour) that had become resident in European minds, were owed. They could then be treated as animals just as one would kill predators that attacked stock. In this animal state they could be subdued with a clear conscious. One escape for Aborigines was to embrace Christianity and become "civilised" and so gained some protection from religious law that inhibits the persecution of fellow Christians. The culture of the Aborigine, with their "dreamtime", did not separate human from nature; they were part of nature, not masters or owners of it. Such cultural beliefs systems have always been considered inferior by western cultures.

The evolutionary process indicates no separation in principle between humans and other animals. While we are distinct in our volume of cultural knowledge passed between individuals this is a difference of degree not a fundamental difference. Other animals have cultural

knowledge. If humans for some reason suddenly disappeared, another mammal could just as easily achieve such a volume of passed cultural knowledge (in time). Ecological belief systems such as "Deep Ecology" have as one of their fundamental doctrines the interrelatedness of all life forms, with humans having no special status from the other animals. Under such a system, the validity of such words as "natural" and "unnatural" could be questioned. These are human terms that are linked to the separation of humans from the rest of animals.

To argue this, consider an offshore island exists containing ground dwelling birds. These birds are incapable of flight as there has been no predation on the island before and the birds have lost their wings. The ability to fly was a genetic cost, a cost not sustainable in the absence of predators. The sea level subsequently drops allowing carnivora to invade (dogs say) which eat all the birds. Today's conservationist may see the disappearance of the birds as regrettable, while still recognising it as natural. Humans played no part in the birds' destruction. The dogs were wild and the drop of the sea a natural geological event. The dogs behaved naturally. Had the invaders been human, the loss of the birds would be a great lament; the humans would be considered by others as having behaved unnaturally. For humans to have one type of behaviour and animals another suggests a fundamental difference between them. The unnatural behaviour of the bird-destroying humans is only a lack of certain memes that might deter another group from the same destruction. Natural or unnatural behaviour would then depend on the volume of memes influencing actions. Such a division of behaviours seems rather arbitrary.

A drought that leaves animal populations decimated or the volcanic destruction of a valley and its animals brings forth no suggestion that an unnatural act has occurred. Prehuman environments have caused death and pain to countless animals. The events occurred before humans

roamed upon the Earth and so they can hardly be attributed to human activity. Predators regularly hunted animals, thereby causing stress and suffering. Disease, injury and the incapacity of old age would have also caused many a lingering painful death. These various "acts of God" are all taken as natural events. Our cave ancestors also hunted and no doubt caused suffering and extinctions. Hunting could not be achieved without cruelty. Animals resisted being eaten. With the primitive weapons such as spears and clubs, a period of suffering had to be endured by an animal before it could die. In Africa, a hunting technique still being used today is to cover a pit into which animals can fall. At the bottom of this pit is placed a large stake which impales the animal upon its fall. The animals will suffer great pain, sometimes for days, before dying.

If humans are not separate from animals then actions by them would also have to be considered as natural. To do otherwise would be to create a boundary that would be difficult to locate. At what stage in the past did some prehuman mammal committing only natural acts evolve to a human form capable of both natural and unnatural acts? Such a boundary could never be found. Therefore acts by humans, as they are evolved animals, can only be considered natural. Concepts that have embedded in them a separation of actions into natural and unnatural become redundant and so should be discarded from our belief systems. For example, the "artificial selection" of cultivated plants to maximise yield could be seen as a natural event. The plant evolved a form sympathetic to its immediate environment, an environment in which humans are present. "Artificial selection" would be dropped in preference for "human selection", and by so doing, the extraction of the component of separation would be achieved.

A major advance in human survival that coevolved with the burgeoning volume of cultural knowledge was the domestication of animals. Instead of wild animals being hunted, humans kept animals. Considerable time

was often spent in caring for these animals. They became an integral part of the village life. Cattle, sheep, camels, fowl, and other animals, provided a year round source of food in the form of meat, milk and, in some cultures, blood. Other products such as wool and hides also assisted survival. Humans moved away from a reliance on direct hunting of wild animals and entered into a relationship with them. By providing a continual source of food, humans were buffered against the natural fluctuations of animal numbers through climate variation. Wild animals could still be hunted if plentiful, but if scarce, domestic animals could be relied upon until the numbers of wild animals increased. Some tribes relied solely on domesticated animals and their lifestyle revolved around their care. Domestication also occurred with plants. Grain could be produced during favourable conditions and stored for use in harsh conditions. Domestication brought stability and through this stability the population increased. The bottleneck of harsh times had been broadened by food reserves. The population increased.

An increasing population encroached on wild lands with a progressive reduction of those lands. From the argument above, this was also a natural process. The human encroachment and destruction is just another part of the Earth's evolutionary history. Human tribes and societies on all continents pillaged others, often putting whole ethnic groups to death. The destruction of land and the repression of other species and conspecifics by our ancestors is a natural process. Some ideologies, such as Buddhism, see animals as sacred and to kill them is to be avoided. (As generalists meat was not essential for humans to survive, otherwise the vegetarian component of Buddhism could never have arisen.) However the destruction of rangelands through the growing of crops indirectly kills wild animals and plants and so such a system is also destructive. We should also consider our current destruction as natural, yet undesirable in terms of our long term survival. This destruction is driven in the main by genetic knowledge, or genetically influenced

cultural knowledge, a knowledge which contains little foresight beyond the length of the reproductive cycle. There are some belief systems now invading past cultural knowledge to include this foresight. Such memes represent "conservation".

Religious memes used such genetic properties of the body as fear and the euphoria from meditation to invade the mind. Memes for conservation may align themselves with genes that promote help towards kin in order to invade the mind. A person has genetic knowledge within him to preference his help to relatives rather than unknown individuals (kin altruism). A conservation meme gains support from these genes to assist passage into the mind. For example, a farmer's thought "I must not clear that block of trees otherwise the erosion which results will devalue the farm and so lessen the inheritance of my children" will be considering conservation in respect to kin survival. Should there be a law (say) that restricts clearing, then such a law may result in an altruistic act from the eye-view of the trees saved (conservation of those trees) which in turn will result in the greater well being of an individual's descendants. This act is not independent of the trees. Indeed it is the properties of the trees, including their soil holding ability, beauty, shade or wind breaking, that has aided their retention. This law would have the genetic desire to help kin as one of its allies in its struggle for acceptance in the mind. The continued success of descendants is a motivation for conservation. (Such conserving laws would only apply to organisms with whom we are not in direct conflict. For example, there is no call to preserve human parasites.)

A mother has genetic knowledge for nurturing and protecting her offspring. In our domestication of animals we extended this compassion to all the animals under our care. The well being of the village depends on the well being of its domestic animals. Just as religions selected for "religiousness" in genetic knowledge, people with a greater genetic

knowledge for the care of domestic animals will be selectively advantaged and so a genetic knowledge of care for domestic animals will arise similar to the mother's care of her offspring. Here genetic selection from the cultural environment occurs. The domestic animals are part of the environment of the village and act as a selection pressure on the genetic knowledge of those villagers.

Now if selection, over thousands of years, causes a genetic knowledge for the caring of animals, and if a person now works in a position not involving animals, then the cultural knowledge for care for animals has been lost, yet the genetic knowledge, which changes at a considerably slower pace, is still in existence. This vestige may lead to that person helping an animal for its sake, not for his own sake. Humans then, have a genetic compassion for animals in themselves rather than a concern dependent on any material gain that may result from this concern. This remains even though the person's family may have, for many generations back, not kept animals. Our desire to keep pets goes in part to satisfy this perpetuation of this genetic myth. Those persons with many pets have a good proportion of the genetic drive for caring. The city person has little opportunity to express this genetic drive, and, like Lorenz's cat that needed to fulfil a desire for stalking mice and stalked those at the farthest end of the room even though mice were running over its forepaws, the keeping of domestic animals fulfils this genetic need. Care for the sake of care cannot happen between other animals as they do not have a history of domestication (except in some species of insects such as ants).

From the eye-view of the human, the helping of a bird with a broken wing is a selfish act. From the eye-view of the bird it is altruistic. The person is unaware that his help is driven by vestige genetic knowledge (earlier referred to as naive altruism). This help is detrimental (a genetic cost) to the person in the sense that it wastes resources. From a genetic

eye-view, a person not helping the bird would be able to out-compete those who help the bird. However, there may be other cultural knowledge for help, including the idea of conservation. Included in conservation memes may be ideas such as "conserve all animals and so conserve the beauty of the environment". Indeed, such memes may have been only able to invade the mind in the first place because of the assistance of genes for care for domestic animals. The memes' alignment with genetic myths improves their chances of success in their struggle in the mind.

A contemporary farmer also has this genetic vestige. But for him it is advantageous in that it enhances his appreciation and ability to manage and operate his farm. Because this knowledge is long standing, the farmer may also help a bird for the sake of helping it. The help for the sake of help has become a genetic habit just as the shrew earlier had the habit of avoiding all red-striped water bugs so as not to suffer the occasional bad tasting one. (But the modern farmer can often be quite ruthless in his approach to animals with this ruthlessness due to intense competition and narrow margins of profit. This type of farming is more like an open air factory and there is often little or no respect for the land and animals. This new attitude represents "materialistic" cultural knowledge and is the subject of the next two sections.)

A similar argument as for the perpetuation of a habit for the care for animals, can be made for care for the land. Cultivation led to an increasing population density and difficulty of movement caused humans to live permanently with one piece of land. Care of that land was necessary to ensure survival. The habit of caring for the land represented cultural knowledge that became part of the environment of the genes and so a selection pressure on them. Persons with a better genetic ability to cultivate plants were selectively advantaged. A practice that was originally cultural has become fixed genetically. These types of

selection pressures emphasise the coevolution of genetic and cultural knowledge. A person may no longer be involved in cultivation yet still feel a reverence for the land. A city based conservationist who argues against degradation of the environment is driven, at least in part, by vestige genetic knowledge for care of animals and plants and the land they occupy. He is arguing for the perpetuation of a genetic habit of extended compassion towards domestic lands and animals. Caring and protection is extended to land and animals in general, rather than those specific lands and animals necessary for survival.

Not all culturalally driven conservation stems directly from past genetic knowledge for the domestication of animals and plants. An economist may make a material argument for preservation; that we should preserve nature as it is a source of wealth to us, in the sense that the forests and seas provide a gene bank for future medical uses, forests are a resource as timber, and vegetation a source of oxygen that is necessary for human health. Memes for such arguments may align with drives for survival in the immediate environment, territorial drives for space, the protection of kin, or the drive to find shelter (built with timber).

Some recent religions and other belief systems have encouraged the separation of humankind from nature. However, while there is a difference in the magnitude of the cultural knowledge passed between humans, and the extent and variety of artifacts produced by humans, most features of human cultural knowledge are also present in numerous mammals. One exception is the genetic knowledge of the care for other animals and land. This knowledge underlies the basis of the conservation movement today.

5.5 The Economics of Environmental Destruction

This section will consider some examples of environmental destruction in order to examine changes in cultural knowledge and so broaden the discussion of conservation in the last section. The European colonisation of Australia was first as a penal colony. Food was always in short supply and so there was a move by the English Government to encourage farmers to emigrate to Australia. Many of these first farmers had no intention of staying permanently but came for adventure and profit. This resulted in economic opportunism, where each person attempted to maximise his profit in the short term (Hoerr 1993a). I hope to consider the events that resulted in the environmental destruction from this colonisation.

Australia was once inhabited by large marsupials (megafauna) which have since disappeared, leaving only their smaller cousins. This disappearance has often been attributed to the arrival of humans - generally believed to be around 40,000 years ago. However megafauna fossils have been dated at 26,000 years old, some 14,000 years after the arrival of the Aborigines, and it is now thought that extinctions occurred due to climatic change, specifically a series of droughts between 26,000 and 15,000 years ago (Horton 1984). Aborigines with their use of fire (Groves 1977), while not necessarily causing extinctions, certainly affected the distribution of vegetation. Human lit fires (Singh 1982) led to the repression of fire-sensitive species, often in rainforest habitats, and "frequent firings by Aborigines over thousands of years have contributed to the development of much of Australia's grasslands and sclerophyll forests" (Christensen and Burrows 1986:98). As a generalisation then, Aborigines caused a redistribution of faunal types rather than extinctions. The number of artifacts possessed by the Aborigine at this time were few. They consisted of flint tools and carved and shaped wooden implements such as spears and boomerangs.

Environmental change came mainly through the use of fire and the introduction of the dingo (a placental mammal brought in by humans).

On their arrival, Europeans found the Australian landscape harsh and uninviting. The soils were poor, the vegetation often erratic and sparse and the rainfall unreliable. There was little food to be found in the "bush" and the first colonies relied heavily on supplies from England. The Aborigines were soon displaced and the best land cleared for agriculture. Resistance by Aborigines was suppressed and they were driven away or shot. The Australian bush was foreign to the colonists and so an attempt was made to create conditions known and understood in England. This included ploughing which was detrimental to the thin impoverished soils. Large trees were seen as a hindrance to agriculture and the laborious task of their removal led to the widespread use of ringbarking.

In northern South Australia there was a rush to produce wheat particularly for a period of good rains from 1870 to 1881. These years were very successful and this led to an expansion of farms well in to areas of marginal climate, almost desert. From 1881 to 1884 there was drought and most farmers lost most or all of their investment. During the period of expansion, mallee (a small shrubby eucalyptus) was slashed and burned for two or three years of wheat farming; when the soil became too poor the farmer simply moved to another area. Mallee stumps were avoided by the "stump jump plough". The removal of cover and the continual ploughing led to soil erosion, whole areas being rendered useless for further farming (Meinig 1962). With the availability of bulldozers, vegetation was pushed into piles or rows and burned. Other areas were burned with regeneration prevented by grazing sheep and cattle on the regrowth.

Overgrazing and trampling of the soils led to wind and water erosion. The removal of trees caused an increase of water table levels and this in turn brought salt to the surface. Water patterns were further disrupted with the inclusion of irrigation, dams, levies, canals and the re-routing of river systems. Opening up of the forests and scrubs as well as greater availability of water led to an increase in open range kangaroo varieties and a decrease in forest varieties. Dams and bores allowed sheep to be grazed well into desert areas where often many acres were needed to support one animal. The increase of water but not of food led to artificially high grazing pressures. Numbers of animals increased in the good years only to die again in the inevitable drought. In the meantime lands were stripped of their vegetation cover and large areas were permanently damaged by soil erosion. Mountain areas were not spared either and although inclined to cold winters or even snow, were used for summer grazing by cattle. Annual burnings caused severe and often immeasurable damage in alpine and subalpine vegetation (Adamson 1982).

Due to Australia's low soil nutrient content, artificial fertilisers were needed and their eventual leaching affected neighbouring soils and waterways. The increased fertility, soil disturbance, earthworks and shortsighted agricultural practices aided the establishment of exotic species. Animals were introduced to create conditions similar to those in Europe. Some escaped or when they were no longer needed, turned loose. Others came accidentally in ships and their cargoes. Birds introduced included sparrows, starlings, blackbirds, skylarks and the cattle egret. Animals such as rabbits, foxes, pigs, horses, goats, camels, buffaloes, cats, cane toads, rats and mice are all significant pest species. Not all introductions were successful. The ostrich was introduced into South Australia in 1920 and by 1950 was in pest proportions, but its numbers have since declined and it is now rare in the wild (Newson and Noble 1986).

Environmental change has been so rapid that some vegetation still exists that predates the European invasion. A study done by Lange and Purdie (1979) illustrates this well. Western myall (an acacia) extends in a band across the western arid rangelands of South Australia. Initially it was suppressed to improve grazing, as well as being cut for fence posts. This large tree grows to six metres with an estimated lifespan of 250 years. It takes about 20 years to outgrow goat or sheep graze-lines. Large trees are still common but the tree's domain coincides with an established sheep growing region. Input of new growth has been severely reduced by the impact of both sheep and rabbits and the woodlands are now in retreat. With all the young trees eaten, it is thought that the woodlands will not survive. The poor health of this woodland is not apparent to casual observers.

By now the reader should be thoroughly depressed. Yet, despite the greater level of environmental damage, today's humans are not necessarily more destructive than their predecessors. Many ancient civilisations mismanaged whole river systems which led to silting and salinity - the fate of the flood plains of the Tigris and the Euphrates (Grainger 1982). Other cultures also practised farming methods that would be looked on with disdain today:

> At the base of the hill once stood the Negro village of Larema, abandoned some time ago on account of the exhaustion of the soil, the natives settling on the heights of Loto, which in their turn will doubtless have to be abandoned in three or four years' time. Durrah impoverishes the soil, and *Phaseolus*, which is freely cultivated, does so to an even greater extent; and, as greater manuring is out of the question, a change of ground is preferred (Emin Pasha, quoted in Schweitzer, vol. 1, 1898:108).

The difference with environmental degradation today is that we have the population and the machines to bring it about on a massive scale. And while humans may be personally less inclined to damage the surrounds, their greater number and, so, greater requirements, and the lifestyle of consumption most have become locked into, all ensure significant destruction. This destruction has slowed recently as people have become more aware of the need to reduce excesses. Awareness has been stimulated by the increasing number of pollution related diseases, damaged habitats, constant graphic depiction of degraded environments and the consequent rise in stress levels as people wonder whether there is a future for their children. Our emerging philosophy of preservation has slowed the rate of destruction but it is still at levels sufficient to cause a substantial drop in human numbers in the long term. To put this process within the concept of this thesis, Europeans arrived and acted opportunistically in their immediate environment. That is, they chose actions that produced the greatest monetary payoff. Many had ventured to Australia only for a short stay where as much money as possible would be made (wheat farming, gold prospecting and so on), and this success would be followed by a triumphant return to England. The trip provided both adventure and prosperity.

Laws sympathetic to the environment could not invade the minds of such adventurers. Consider some law such as "mallee soils should not be ploughed so as to expose the soil to erosion". Say also that by not ploughing yields are lower in the initial few years yet the same land will produce greater yields if yields are averaged over a longer period. Now as the farmer can move to another block when one is exhausted there is greater profit in ploughing the soil in a way to maximise profit. A law for conservation cannot invade the mind as it is not strong enough to overcome the drive for immediate profit. For such a law to survive it would need to align with genetic drives for preservation of the land, a

drive that would be expressed if the farmer intended permanent residency. Other cultural knowledge sympathetic to the environment will also assist such a law. For example, say the farmer grew up in the region and had developed a "love" for the land and lifestyle. Cultural knowledge for care would have time to develop and so these memes would support the memes of the law invading the mind.

The actions of the wheat farmers are more akin to the "slash and burn" of early agricultural practices. Here the people had limited cultural knowledge with the inherited "slash and burn" method being a component of this cultural knowledge. Their actions were dominated by needs for food and shelter; genetic knowledge. The evolution of the knowledge of generalists is characterised by a shift in decisions derived mainly from genetic knowledge to being derived mainly from cultural knowledge. For humans there was a selection pressure for a greater ability to know environments through cultural knowledge. This progression can be seen in the changes of the methods of obtaining food; first hunting and gathering, later shifting subsistence and finally intensive farming. The European wheat farmer came from a region of intensive farming yet reverted to shifting subsistence in northern South Australia. Economic gain was not the single cause of such farming practices. Many of the colonists knew little about farming; it is an acquired skill that farm hands take many years to learn. Once arable land was exhausted, wheat farming was abandoned in many areas and these became sheep grazing properties. The better wheat lands were retained by farmers prepared to farm intensively with a rotation of crops. Unfortunately the initial rush of farming caused considerable damage that can still be seen today in the form of sand dunes made through the wind blown top soil from the destroyed ancient mallee scrubs.

For the wheat farmer, the land was a resource to be exploited. Leaving farming, I will now consider the growth of cultural knowledge that

occurred through the exploitation of another resource; fossil fuels. Intensive farming allowed more and more manipulation of the physical environment and so support for a greater population. It was achieved by shifting the burden of labour first to animals (such as the ox and horse), then to machines through steam power and fossil fuels (Thomas 1983). The volume of food produced was so great that few people needed to be farmers and the activities of others could be diverted to making artifacts and providing services.

Fossil fuels allowed industrialisation, a period of increasing artifact production. A person designing a new artifact that sold well would gain prosperity. Memes for such an artifact could align themselves with genetic drives for survival, for status, for assisting kin and so on, and so easily invade the mind. The production of steam engines and other devices needed for industrialisation led to a movement of the workforce into the cities. From a cultural eye-view this represents something akin to adaptive radiation. The new niche exploited by the memes was a world awash with fossil fuel energy. People competed to find uses for these new sources of energy. Any artifact that used a pre-existing energy source (windmills, the horse and buggy, sail boats and so on) became an immediate target for replacement by new artifacts that used the new fuels, coal, oil and gas, which were a source of "food" to drive cultural expansion.

New machines that used fossil fuels could be devised and tested. The success or failure of these machines prompted further variations which were again tested, and so a series of progressively more efficient artifacts were made. These artifacts were in turn part of the environment of the new memes and so a selection pressure on them. I will now make an analogy between this process of industrialisation and a biological process to demonstrate the underlying identical mechanisms (see Hoerr 1993b).

Imagine an island with a community of flora and fauna. An exotic plant invades which has flowers that contain a rich nectar. The nectar is now an unoccupied niche available to any animal for exploitation (with pollination the flower's reward in any mutualistic relationship formed). Say a bird, that previously utilised a number of other sources of nectar, gains, through directional selections, a genetic knowledge of this new niche. It now uses exclusively the new source of nectar. As the plant was in the process of colonising the island, its increasing numbers will produce an increasing volume of nectar. The population of the newly specialist bird will also grow. The bird may also undergo changes through its specialisation of feeding from this flower. For example, should the flower stem become longer, the bird's beak will follow.

Now consider the extinction of this plant from causes that have nothing to do with the bird's feeding. If the plant undergoes gradual extinction, the selection pressures will be reversed. Given the necessary variations, the bird will regain its genetic knowledge of previous plants. (This past niche will be occupied by other species and so the bird may face considerable competition.) Those birds that had become dependent on the nectar will find themselves spending more and more time searching for the flower and, through this, previous sources of food may be rediscovered. The plant's progressive scarcity is a selection pressure away from the use of this flower. If the bird can still feed from these other plants, then, as the preferred plant becomes rarer and rarer the birds will rely on it less and less. When the plant has vanished (given that the original food sources are still available) the birds should be back to approximately their condition before the invasion of the plant. However the total amount of food now available after the loss of the new flower may be considerably less. As a consequence a substantial drop in the numbers of the birds would occur.

The other possibility, a sudden extinction of the plant, may result in the similarly sudden extinction of all those birds whose life has become dependent on the plant. Sudden environmental change is thought to be the main pressure causing redistribution, extinction and birth of new species. The loss of the flower would be a sudden environmental change for the bird. The bird's beak that is an adaptation to the new flower may no longer be suitable for other flowers (say). The bird has no genetic knowledge for a different lifestyle requiring a different beak. The more sudden the loss of the flower, the greater the likelihood of the bird's extinction. New genetic knowledge is slow to come and this rate of gain in knowledge may not be sufficient.

Like the bird moving to the use of the introduced nectar, humans moved to the use of fossil fuels. Wood, horses and then fossil fuels were sources of nectar that became available to the human race. Humans, in moving to these fuels, satisfied genetic and cultural drives. Their use enhanced survival. By moving in this way, physical work that would have been necessary for living (such as obtaining food and shelter) was done instead, partially or wholly, by artifacts that were powered by fossil fuels. Such a displacement of work and an improvement of living standards allowed populations to grow to the levels that currently exist. But increased growth needed an increased use of fossil fuels. To maintain the current population a certain level of fossil fuels needs to be consumed. This consumption can only be avoided by new cultural knowledge that allows new fuel sources to be used in combination with population control.

A further possibility is that our fossil fuel use may change the environment through pollution and so make it difficult to return to conditions prior to fossil fuel use. This is equivalent, in our analogy, to the nectar-producing plant going to extinction and yet, before doing this, having successfully competed with, and so destroyed, the previous

plants that provided nectar (say). The birds, in abandoning the declining plant's nectar, cannot return to the nectar from the original extinct plants.

As the scarcity of fossil fuels increases it follows that we should be lessening our reliance on them so as to avoid a sudden population drop upon their exhaustion. New artifacts that do not have a reliance on fossil fuels are needed. Because we have specialised in the use of fossil fuels, when these disappear we will be left with a system that requires a large energy throughput, but without the energy to maintain such a system. (I discount here the use of nuclear fuels which few countries see as a viable alternative.)

While conservationists are advocating a slowing of growth in tandem with a move away from fossil fuels to cyclic fuels (solar, wind, tidal, hydroelectric, ethanol, and so on), economists still suggest that further growth in the economy is necessary. As almost everything is made or carried, either directly or indirectly, by the energy derived from fossil fuels, a suggestion of growth is a suggestion of increased use of fossil fuels. If the analogy advanced above holds, it follows that this is the exact opposite of the direction that we should be taking. This underlies the danger of making decisions based on what is economically best in the immediate environment. Like the many animals with irreversible genetic knowledge, following the easiest path in the immediate environment may result in cultural knowledge that is a blind alley from which there is no return. Fossil fuel use could be a cultural blind alley for humans.

Fossil fuels are used to produce numerous artifacts, not just for the production of food. Food is needed by the body for survival and so cultural knowledge for its production exists in mutualistic relationship with the genetic body. However as the food is produced by fossil fuels, our long term destruction may result. The cultural knowledge for food

production is parasitic on genetic knowledge for kin altruism. In the long term, direct descendants may not survive. The use of fossil fuels is then ultimately parasitic on the genetic body.

Many other artifacts exist, the memes for which is also parasitic on the genetic body. For example, consider the mining of gold. It contains a considerable mythical component. Gold is valuable for symbolic reasons rather than its use for making functional artifacts. It is like the sacrifice of our primitive religion. The memes driving its mining are selectively advantageous in the minds of a few: those people of power in the community. Gold's malleability and resistance to oxidation originally attracted uses such as the decoration of the body and the gold leaf covering of temples; then its use as coinage has led to it becoming the favoured metal for the backing of currencies. It is a symbol of economic power for people of higher standing. Today it is extracted at the cost of vast amounts of fossil fuels. An alien observer would probably view this use of precious fossil fuel reserves to dig up gold ore, concentrate it, and then store it again in another location, as a sign of exceptionally poor insight into one's own activities. Gold mining is simply unjustified given that very little of the metal is actually put to some physical use. For the most part it is merely stored, requiring further humanpower to prevent its theft. Gold mining could cease with no damage to human society except the loss of employment for those involved with its mining and storing, and these people could be employed more profitably elsewhere. Like the sacrifice, gold is parasitic on the general genetic body. Gold mining overwhelmingly benefits the "priest" class; those involved in its mining. These people must be maintained by the remaining population and so represent a loss of living standards to that remainder. The gold mining community is parasitic on this remainder, returning it no positive payoff, only a metal of symbolic value. Just as a church building is the phenotype of religious memes, some of which are parasitic, the refined gold is the phenotype of the parasitic gold memes (such as the idea that

gold is valuable). In contrast, the mining of iron (say), provides material for making farm implements, houses, cars and so on, all artifacts that contribute more to the genetic body. (Although these too have some parasitic content in their use of fossil fuels.)

The mining industry would counter the above argument by stressing that gold is used; it is the basis for our currency and a method of barter between countries. This however is an appeal to gold's mythical value rather than its real value, a distinction which is crucial. Something of mythical value can be abandoned along with the cultural memes supporting it so there is no net change in prosperity. But this is not easy. Many of these memes will be well embedded in minds. If gold mining was abandoned and if aluminium or iron were adopted as the unit of wealth, no loss of human viability should occur. If the mining of iron were abandoned there would be a loss of viability. Our civilisation would need complete restructuring. Artifacts of symbolic value in past civilisations that are still produced today at the expense of fossil fuels could profitably be abandoned.

The industrial nations have already destroyed a considerable part of their natural environment and through this destruction have produced the wealth necessary for their current standard of living. Destruction results from the invasion of mutualistic and parasitic memes. Parasitic memes include those that have only symbolic value (such as the gold meme above) and need fossil fuels to drive their expression (for example, some religious memes, modern city design, thermally inefficient housing, and so on). Mutualistic memes will include activities that are beneficial to the genetic body in the short term, but will leave a degraded environment for those who follow; that is, they are parasitic in the long term (for example, the wheat farming discussed above, unsustainable logging, drift netting, loss of topsoil, and so on). Other mutualistic memes will drive activities that give a benefit for the holder of those

memes yet do not leave a degraded environment for those who follow. An example would be sustainable agriculture. It is the proliferation of these memes that is the goal of the conservationist. In the last section I argued that a proportion of the drive for conservation resulted from vestigial genetic knowledge formed by directional selections for domestic animal and land care. Yet these genes are now parasitic on the genetic body as they code for a behaviour not directly beneficial to it. Conservation will only occur if parasitic memes or genes override the drives of the genetic body. The genetic body maximises reproduction, and any memes opposed to this are parasitic.

A fundamental idea in biology is that a population of organisms will expand to use the food available to it. Through mechanised farming the food supply increased markedly with a corresponding increase in population. Poor sanitation and plagues normally control such increases but these were progressively avoided through improved medical knowledge. Can population control occur today without the help of disease? A meme "have at most two children" to invade minds would need to overcome genetic drives such as the desire to reproduce. The meme will have to also compete with religious memes such as "contraceptives are immoral" and "God will provide".

Children are also an asset to a family. When they reach working age they can help with the money they earn. In many societies children will eventually care for their parents in their old age. For a society, a growing population may be good for business. Growth implies an acceleration of artifact use and so an acceleration of the wealth of businesses producing such artifacts. However, a continually growing population is not possible in a finite world so at some stage it must be either controlled through new laws or else it will be controlled by natural forces such as famine and war. This already occurs to some extent in many countries.

For population control, new memes such as "to produce more than two children is a request for more of the Earth's resources than to replace oneselves" must be able to invade a couple's mind. Couples wanting more than two children are expressing a form of material greed. They desire an accelerating use of materials for their offspring and the offspring's offspring, and so on. This expansion is, of course, natural, and the only choice from a genetic eye-view. Genetic knowledge is selfish and self sacrifice cannot evolve. Memes that restrict the number of children can only be parasitic on the genetic body. From the eye-view of the genetic body, the more offspring the greater the spread of genes. For parasitic memes to invade, the greater the volume of resident cultural knowledge present, the greater the invading memes' chances of success. Population control and conservation then, are made more likely through education.

The moral "have two or less children" will help conservation memes struggle against such beliefs as the religious idea of the unqualified sanctity of human life. The Pope's refusal to allow the use of the condom is the selfish interest of a religious meme; it is a weighted law in that it is the opinion of one man (or, more probably, the Vatican hierarchy). From the religion's eye-view the restriction will increase the number of Catholics in ratio to other religions who practice restrictions. Memes that may have invaded religions in the past and suggested that family size should be controlled, could have led to that religion being overrun by other religions that did not restrict birth control (however it is hard to believe that the Pope has this in mind). Memes forbidding birth control may have successfully survived in some previous cultural environment, an environment no longer existing. This is similar to an active but archaic law that evolved in some previous environment. The Pope therefore refuses birth control on the basis of a past cultural habit. He would argue that he is only following tradition or "religious law". Religious principles have their origin in local events. Moses' ten commandments were a set of

guides for his people in their exodus from Egypt. The tenth commandment "you shall not covet your neighbour's house; you shall not covet your neighbour's wife, or his manservant, or his maid servant, or his ox, or his ass, or anything else that is your neighbour's" is a law clearly designed for cultural conditions of the time.

The use of beasts of burden, wood, and fossil fuels, has allowed a decrease in time devoted to farming and so an increase in time devoted to cultural novelty, as can be seen by the rapid increase of artifact production. Yet this increasing dependency on fossil fuels, a finite energy source, endangers humans through the artificially high population that has arisen in response. New laws and morals are required to limit the spread of some memes, as well as to override the genetic knowledge that drives this population increase.

5.6 Materialism

In the last section I argued that fossil fuels provided the energy for the production of an array of artifacts. The fuels were an unoccupied niche that the human occupied. The artifacts allowed a higher ratio of food to be produced per individual and so the population rose. What are the cultural processes that *caused* this material drive? Part of this answer is curiosity. Animals naturally seek unoccupied niches. The artifacts produced allowed the exploration, through new knowledge, of the variety of uses artifacts could be put to. Farming implements allowed the production of more food, transport vehicles greater mobility, and houses more adequate shelter. Yet this is not the full answer. Some people accumulate materials for the sake of accumulation rather than any use. Ancient genes that drive for status and power contribute to this accumulation. Our exaggerated material requirements are in part the result of a runaway desire to achieve a high ranking through wealth. Rank in the past allowed an increased chance of survival and successful reproduction. Now genetic knowledge for material gain will be part of

the environment of new memes that struggle to survive in the mind for acceptance and so the memes that do survive will reinforce (or align with) this genetic knowledge. This section will investigate the nature of those memes.

The sacrifice and fast of our primitive religion allowed a "priest" class more privileges than the common person. Indeed priests may achieve power and wealth by creating memes that survive in their minds and that are able to infiltrate the minds of the common person through hitchhiking on genetic knowledge such as fear and the euphoria of meditation. These memes may be enforced on an unwilling population through laws, regulations and morals, by a priest class that has accumulated power in the past (a weighted belief of an elite class, say). The individual priest need not necessarily be aware of this. He may be genuine in the propagation of this meme to other people. But the meme will only survive initially in his mind if he perceives some positive cultural payoff, even though this gain may not eventuate. Work must be done by the community in order to survive. Naturally those doing the *least* work and gaining the *most* privileges are the elite class. The memes that result in the division of work are just those successful memes of the priest classes. This is to be expected, as these memes are mutualistic to the priest's genetic body. As stressed earlier, before memes can succeed a certain volume of supportive cultural knowledge must accumulate. This volume must be such that a level of communication occurs between people so that "priest" memes can be spread. The memes "fast" and "sacrifice" are parasitic on the common person yet mutualistic in the minds of the ruling class. Without a strong social structure and the threat of priests defecting against non believers, these memes would not have spread.

Just as religion has a priest class, the cult of artifact production, materialism similarly allows one class of people to gain at the expense of

another. The original purpose of the brain was to better know an environment during the organism's lifetime through new cultural knowledge and so achieve a better exploitation of that environment. This environment includes conspecifics. Certain memes will advantage a person over other memes and the person who comes to have the "best" memes will be selectively advantaged in terms of status and so reproduction. (This drive for material gain need not result in a large family as many successful people often harbour memes for limited family size. Here the desire for materials has overridden the genetic desire for unconstrained reproduction.) One section of a population can control another section through laws that direct an artificially high level of material use.

For example, say a person wishes to build a house and so purchases a standard block of land in a residential area of some city. If he applies to the council for permission to construct a tipi or wattle and daub house his request will be probably disallowed. The reasons might be many. The construction may be less than the minimum permitted size for a house, or the simple design may be gauged as "structurally unsound". In the latter case, if it is proposed to build a wattle and daub house by placing poles in the ground and rendering the gaps between the poles with clay (a practice used by humans for thousands of years), the council may reply that the structure is not sound because the poles will rot in ten years or so. A reply from the builder that if the poles start to rot the structure can quickly be rebuilt is not likely to be accepted by the council. Today most councils insist that a house can only be built that has a lifespan longer than our mud hut, a position that is not typical of our evolutionary history. Here the council enforces a particular level of artifact consumption. It may even insist on a particular style of house being built, on the basis that alternative structures will "devalue" those other houses surrounding it. The owners of these houses may complain to the council if such a structure is proposed. A particular level of artifact

use has been established within the community and those proposing to use a significantly lower level of artifacts are seen by others as playing a "defect strategy". They are cheating against the community. The strategy of the builder is distant from the average strategy (or cultural mean) and so laws have managed to invade the minds of the community to prevent a lower level of artifact use. "Changes which threaten the perpetuation of the pattern will be the most vigorously resisted" (Goodenough 1995:303).

On environmental grounds, simple structures would require less fossil fuel to build in that they require fewer manufactured artifacts. A conservation minded council might therefore be expected to encourage the minimal use of artifacts. Yet the council collects rates that are calculated as a percentage of the value of the house. Lower value houses will reduce the council's income. This will undoubtedly weigh tellingly with many councillors, though perhaps not all would reject a building for this reason. But council laws may have evolved in a previous environment and were argued for by councillors from that earlier period. These original arguments may be forgotten while the laws remain. Laws for minimum house size may have been formed when pollution from fossil fuel use was not so evident. Novel houses of low artifact use may therefore be rejected for a combination of reasons; laws against defect strategies; outdated laws where council members lack the necessary understanding of changing conditions appropriate to make adaptations; and economic pressure to continue a high level of artifact use. Should everyone build simple houses, ride bicycles to work, and so on, the economic structure of our current society would collapse. It is in the economic interest of the business "priests" of society to maintain a high level of artifact consumption through laws suppressing low usage, and advertising encouraging high usage, just as it is in the interests of religious priests to maintain worship and religious beliefs and suppress new religious interpretation. The power of the business executive is proportional to artifact turnover.

A flourishing building industry is a sign of either population expansion, population relocation, the short life span of houses, or a combination of these. The modern short lived house is separate from the short lived wattle and daub house above. In terms of fossil fuel use, the modern house vastly exceeds wattle and daub houses. Over the last hundred years there has been a tendency to build houses of progressively shorter life spans. The modern house in Australia has a dubious lifespan; often repairs being needed in less than ten years. Steel in foundations is subject to oxidation and so corrosion. Heavy foundations move and crack. Design is usually poor and variety limited. Novelty in design slows production rates. The houses suffer from poor workmanship with speed of completion, and therefore maximum profits, being the main goal. Speed is achieved through parts being prefabricated which allows a machine to assemble the components on site. Now the precision cut stone walls of the Incas have survived for *thousands* of years. With our technology it should be possible to build equally long lived houses. In this case, just as full recycling of materials would reduce the number of mines, well built houses and a stable population would require a minimal housing industry. This could be achieved by the use of materials such as mudbricks where the soil comes from the house site, thereby minimising transport and processing. There is, therefore, a small fuel input per house. If houses could be built with a thousand year life span, and the population was stable with an average lifespan of eighty years, then a house would only require rebuilding every twelve generations or so.

These wasteful building practices are characteristic of society as a whole. An industry makes a product, then "sells" it to the public by telling it of the benefits that will be gained by its use. In doing so the industry appeals to knowledge resident in the minds of the people. The cultural memes encouraged by business priests are variations on the notion that

"more materials are better than less". A person with a bigger house or a house with more exotic artifacts is considered by our society as having "achieved more" in life. Such a meme aligns with the genetic drive for status and power. Eventually the house and the exotic artifacts that result become part of the lifestyle and the person loses the ability to live in any other way. The offspring learns the same message.

Advertisements for various artifacts stress an individual's need for them. Say a person decides to buy a new car. He might buy it because his present car has mechanical difficulties, or the new car may have better fuel consumption, more safety features, or be the latest design. All these attributes "liberate" him from the properties of the old car (or at least this is what he is told). He buys a new car because he believes it is better for him. An advertisement for cars may use phrases such as "move up to the car you have always wanted". The advertiser hopes that this meme will successfully invade the mind. Use of "move up to" aligns itself with drives for success and status. "Move up to" implies that the present car owned is inferior. In our upbringing to own inferior things is associated with failure. Children fighting in the playground do so for control of the biggest and brightest artifacts. Clearly the struggle for rank has a large genetic component. Use of "the car you have always wanted" reinforces the idea that everyone would opt for a new car if they had the chance. In conflict with this message are resident memes such as "can I afford it ?". This meme and associated ones for thrift battle it out in the mind, with a car being purchased or not as the outcome. Had a person received different knowledge he may have been better equipped to override the memes of advertising and so not change cars regularly or even have a car at all. A high consumption of artifacts ensures a large revenue for government. Lower consumption of artifacts means a lower wage is sufficient for survival and so lower tax is paid to the government.

We could also consider modern farming. Intensive farming has undergone considerable change in the last few decades. The traditional farmer used complex agricultural methods of alternating crops, resting fields by keeping them fallow, growing legumes for nitrogen and ploughing these into the ground, root grubbing by pigs, and numerous other techniques and skills that kept the farm productive with a minimum of outside assistance. The modern farmer need understand none of this. The soil is just a medium to hold the crop and stop the plants from being blown away. All the fertility comes from additives to the soil, additives made by various chemical companies each trying to promote its products and methods over other companies. Large single crops encourage insect explosions. Some insect populations have become specialised in respect to commercial crops (Singer *et al.*, 1993). But a farmer with a problem need go no further than the chemicals of his supplier, though many of the chemicals that have been used for spraying insects were found later to have a considerable toxicity to humans and other wildlife. This system allows people with little traditional knowledge of farming practices to become farmers. The farmer's level of appreciation and affection for the land was minimal and as a consequence Australia suffered severe erosion and damage. Modern farming is also similar to the slash and burn wheat farming where blocks were abandoned once fertility declined and another area cleared. There was no attempt to retain and build soil structure and fertility. Modern farming is also economically opportunistic rather than sustainable. The modern farmer must have faith that the companies are supplying him with the best information needed for his farm to be successful, so that he can fulfil other goals (such as raising a family). His success in life depends on these bodies and their products. The chemicals and machines are the faiths of a religion or the artifacts of a building industry. He blindly accepts them as functional components that will bring success and stability to his life. Like an individual's loss of medical knowledge and the accompanying ability to cure himself, the farmer has handed

control of farm operations to various companies that periodically release new grain types, fertilisers or sprays, and the farmer has no longer the knowledge to question their soundness. The person who finds himself in hospital after an accident takes the doctors on trust and rarely questions recommended treatment. Indeed, doctors often take affront to any questioning of their methods. Chemical companies often take affront if a farmer questions the toxicity of the sprays and their soundness to human health.

The same argument can be made for an institution. It is in the interest of the members of an institution to ensure its survival. For example, the British nuclear industry suppressed the development and implementation of the use of wave energy as an alternative power by suppressing and distorting information that was needed by committees for deciding the future of wave energy projects (Jeffery 1990). The scientists, aware that their recommendations were not heeded, would see the suppression as altruistic in the minds of the members of the institution but selfish in respect to the general public. Here the weighted beliefs of a small number of officials who were in a position of power overrode the belief of a large body of scientists that wave power was a better prospect for Britain.

A business person who produces a particular product calls attention to its attributes rather than its defects when it is marketed. Selective evidence is used to support the validity of a product. This is done by only drawing attention to research favourable to their product, or else giving research grants to people who can be relied upon to arrive at the proofs that the producer needs. The tobacco industry has regularly funded research favourable to its promotion. The industry donates money to sports in an attempt to associate health with smoking. Many people buy advertised products only to find out the defects later. This form of invasion by memes is subtle and difficult to challenge, hence its

survival. For some products, such as smoking, often laws are made that ensure certain standards. Here a law is possible because the those making the law realise that they too can be the victims of these products. Often business "priests", through their wealth, can be part of these law making panels, or at least they can have a significant influence on the outcome. A common threat is to suggest the closure of a factory which would put many people out of work (all of them voters) should a law against pollution (say) be enacted. A defective product is parasitic against a society yet mutualistic to its maker. Similarly, in biology the mimic cleaner fish feigns a mutualistic relationship with its host only to take a large bite of its actual flesh. The defective product feigns just such a mutualistic relationship; the buyer assumes a benefit from the product, the product is benefited by reproduction, and the seller benefited by profit.

An election also involves advertising, with the candidate the product of purchase. A government minister will claim that, if elected, certain actions will be taken by him to alleviate various sufferings and hardships of the populace. All too often, like the attributes of the defective product, the minister fails to deliver his promises.

There need be no such pretence where the election is one in name only, and opponents have to be repressed through the prevention of advertising, arrest or intimidation. In Malaysia the Minister for the Environment and Tourism is also the manager of one of the largest logging companies: "the sad and undisputed fact is that virtually every state politician in the ruling parties [in Malaysia] is financially involved in the industry, which is itself run in an utterly corrupt and unsustainable way" (Hanbury-Tension 1990). The minister is the mimic cleaner fish that takes a large bite of the nation's wealth. Not surprisingly, no western government comments on these excesses as their economic relationships with such countries are of paramount

concern. The leaders of these governments choose actions mutualistic in their eye-view, yet parasitic in the eye-view of the general population.

Earlier, in our consideration of medical knowledge, we saw how genes and memes competed with each other for control of a particular piece of knowledge. A genetic control of a particular disease could be taken over by cultural knowledge. Useful knowledge guaranteed reproduction and so survival for a meme or gene. Through various directional selection pressures some genetic knowledge was transferred to cultural knowledge. Yet the genetic knowledge lost was not necessarily taken up by the mind within that same body; rather it was taken up by minds external to the body (the minds of various doctors). The person with the genetic disease did not have the knowledge to cure himself, rather he was cured by a doctor. Similarly, in modern farming, the building industry, the production of artifacts in general, and most other belief systems, cultural knowledge of the individual is transferred to cultural knowledge of the "priest" class (priests, businessmen, scientists, politicians, companies producing farm chemicals, and so on). For the individual this loss of knowledge represents a loss of control of his genetic body, with this loss often leaving a person feeling confined or constricted in today's society. He is often locked into ownership of numerous artifacts at an early age (a house, car, and so on) and spends the best part of his life repaying debts. He may also be locked into a restrictive religion, or suffering under poor government. This state of the common person is the result of the efforts of "priests" to maximise their payoff. It is not until a family's car breaks down, their electricity is cut, a parent loses his/her job, they become sick, they attempt to build a house, that they realise how helplessly they are controlled by and dependent on external knowledge in the minds of others. This dependency is increasing in our bureaucratic society.

If every family unit had an equal-sized plot of land on which they had to work to produce food, the work load would be evenly spread. Here the level of cultural interconnection is such that parasitic memes from a priest class would have difficulty invading. Families would act individually, so there would be no interconnectedness. In a system where artifacts are traded, the complexity of the society increases till eventually it reaches a level where parasitic memes (like the memes "fast" and "sacrifice" discussed earlier) can invade. These memes must still win the struggle in at least some minds and it is in the "priest" class that they are successful. This class, through these memes, can increase one or more components of status, power, reproduction, happiness and so on, at the expense of the common people by forcing or coercing such memes into their minds through warfare, regulations, laws and morals. Materialism, like religion, is a belief system that leads to differential sharing of the world's resources.

Earlier (section 3.5) I argued that nature was not always "red in tooth and claw". Here rabbits that had suffered a drought or some other catastrophe might experience many generations wherein little competition is experienced. Their population is expanding and the natural cover of grass is an inexhaustible food supply for the time being. Eventually competition will return, but several generations of rabbits may grow, reproduce and die without ever experiencing hardship in obtaining food. Humans too, through the fossil fuel driven production of artifacts, are able (in many countries) to produce ample food so that scarcity is never known. This abundance naturally coevolves with a population increase. Like the rabbits, the human race is only now just beginning to experience a return to competition for resources.

As argued earlier, the production of salt, fats and oils, and sugar is also part of this over-production and our desire for these has not evolved an upper bound. In modern societies there is a tendency to over indulge in

these foods to the detriment of the genetic body. Similarly, humans have rarely expressed satisfaction with any particular material level, always scheming (seeking new memes) to accumulate more. It was no doubt uncommon to have materials in excess in ancestral environments so our accumulation of these also evolved no upper bound. The volume of materials collected by a western person is unlikely to be necessary for his survival, or, what is paramount to the genetic body, the production of offspring. Those countries with the smallest volume of materials per person, the third world countries, often have the largest families. That such a drive can out-compete our most basic drive, reproduction, indicates how established these memes have become.

Yet, without this runaway production of artifacts, which occurred more by "luck" (that a varying porosity of sediment layers allowed trapped pockets of decayed vegetable matter) than by human ingenuity, complex artifacts may never have evolved or would not have evolved so quickly. A certain critical level of artifact evolution was necessary for the development of computers. If there is going to be a progression of nested life forms things could not have occurred more conveniently. In terms of the evolution of variety, the use of fossil fuels is advantageous. Even environmental pollution, although a problem in itself, will lead to an increased rate of research and so novel solutions against pollution, just as the rate of artifact novelty increases during war. Through pollution and overcrowding the rate of production of new memes will be increased.

Belief systems such as materialism and religion, function identically in their mechanisms of interaction and reproduction. The faiths of religion are the artifacts of materialism. People take it on trust that the use of such artifacts will increase their standard of living, just as they take it on trust that faiths will secure satisfying lives and an afterlife.

5.7 Evolution in Literature

Much of our literature is an account of the interaction of humans, and so, indirectly, the process of evolution should also be described. As all actions and thoughts are this ubiquitous evolutionary process, life and evolution are synonymous. Dreaming and thinking are the struggle of units of knowledge in the mind. A business transaction, an argument, cooking a meal, writing a book, a sports game, are all the expression of units of knowledge that have been successful in their struggle.

Literature is a narration of actions and thoughts and so provides an insight into how people understand evolution. An expression such as "the devil take the hindmost" reflects our genetic understanding that not all entities survive this struggle. It is understood by all animals; farm animals struggle to be the first to food, particularly if it is known that the food is in limited supply.

One book should be sufficient to demonstrate the evolutionary process in literature. I will choose a book of short stories by W. Somerset Maugham (vol. 4, 1951). Other books would have served just as well. To comprehensively treat the development of the characters and plots in these stories would be too lengthy a process so I will restrict myself to the analysis of a number of passages.

> Some people read for instruction, which is praiseworthy, and some for pleasure, which is innocent, but not a few read from habit, and I suppose that this is neither innocent nor praiseworthy. Of that lamentable company am I (1951:9). ...
>
> He belongs to that class of simple, expeditious, positive and dull persons who above all things in the world worship order, and find in this a justification for their existence (1951:214).

A habit once formed becomes a pattern for a person's life. These are a person's embedded memes that s/he knows from experience will return a particular benefit. Novel memes, while they could return a higher benefit, involve a certain risk, and this risk is such that these memes may not survive in his/her mind. A bigot has entrenched memes and no amount of reasoning will persuade him/her to abandon these. If subject to persuasive arguments, his/her mind closes and prevents the entry of new memes. Entrenched memes are usually formed in the early phase of a person's life. The first language learnt, the mother tongue, is a set of entrenched memes. The endemic religion also becomes well embedded in most cases. A person usually feels most comfortable with the language and religion of youth. These well embedded memes are obstacles to freedom.

> The lives of most men are determined by their environment. They accept the circumstances amid which fate has thrown them not only with resignation but even with good will. They are like street-cars running contentedly on their rails and they despise the slightly flivver that dashes in and out of the traffic and speeds so jauntily across the open country. I respect them; they are good citizens, good husbands, and good fathers, and of course someone has to pay the taxes; but I do not find them exciting. I am fascinated by the men, few enough in all conscience, who take life into their own hands and seem to mould it to their liking. It may be that we have no such thing as free will, but at all events we have the illusion of it. At a cross-road it does seem to us that we might go either to the right or to the left and, the choice once made, it is difficult to see that the whole course of the world's history obliged us to take the turning we did (1951:173).

Maugham asks whether there is really free will or whether we just have the illusion of it. This same question is raised in the appendix in a consideration of randomness and determinism. I come to a similar conclusion: that there is indeterminism from our eye-view, but this does not imply a general indeterminism.

The reference to 'cross-roads' is a reference to the random element in life. The 'slightly flivver' is the car that allows itself to be largely subject to random elements. In contrast, for the habitual person, the random element is not nearly as influential. A comfortable life, once obtained, is difficult to break away from. A set of memes has become entrenched. To break away entertains a certain risk that many fear taking. Those persons who have had variety in their upbringing may not have memes so embedded, and the entry of new memes is easier.

> The extraordinariness of a man's life does not make him extraordinary, but contrariwise if a man is extraordinary he will make extraordinariness out of life as humdrum as that of a country curate (1951:278).

Maugham is saying that unusual cultural knowledge will have little effect on a person of little genetic talent. On the other hand, an unusual genetic background will generally override an ordinary cultural upbringing. If new extraordinary memes cannot come from outside, they will be generated from within.

> But human beings are incalculable and he is a fool who tells himself that he knows what a man is capable of (1951:115).

A person's knowledge can never be known completely by another. This is particularly so because new ideas are being thought up continuously.

A person who thinks of acting in one way at some instant, may think of acting completely differently a second or so later.

> I have never seen a sign that there is in the scheme of things an intelligent purpose. If the universe is a contrivance of some being, that being can only be a criminal imbecile (1951:45).

This is a rejection of the various religious memes that call for the recognition of some maker of the universe. Considering the suffering and pain in the world, and remembering that this also occurred to animals before humankind, it seems incredible that such a state could have been purposely made.

> The will needs obstacles in order to exercise its power; when it is never thwarted, when no effort is needed to achieve one's desires, because one has placed one's desires only in the things that can be obtained by stretching out one's hand, the will grows impotent. If you walk on the level all the time, the muscles you need to climb a mountain will atrophy (1951:187).

The rate of evolution of both genetic and cultural knowledge will depend on the rate of environmental change. A uniform environment, either physical or mental, that undergoes little change will result in an optimum knowledge with new ideas of lower benefit than current optimums. A variable environment will advantage offspring with new knowledge for this new environment.

> Besides, as we all know from our own experience, it is never unpleasant to talk about oneself" (1951:24).

Each person has a unique knowledge and therefore unique experience of the world. Conversation necessarily represents this eye-view of the world

6. Conclusion

The main argument throughout this thesis has been that there is a single process separating life from an original dead environment. This process is the differential survival of variations of units of knowledge. These units have the properties, multiplication, heredity and variation.

Because the world contains such a variety of chemical elements, mineral structures, climates, and landforms, the types of organisms existing can be expected to show great variety. The ability to know these environments was first obtained through genetic knowledge. Genetic knowledge that was influenced in its development by environmental information gave organisms some flexibility, but change in this flexibility was limited to the generation length. Later, the brain increased variable behaviour during an animal's lifetime from the storage and reuse of cultural knowledge that was for personal use only. As development of the brain increased, nurturing and socialisation evolved, allowing some animals to pass cultural knowledge to others, in particular, offspring. This new living unit of knowlege, the meme, interacts with genetic knowledge in the mind with this interaction the thoughts of the animal.

The memes progressed in complexity with some groups of memes manifesting themselves physically, as artifacts. One such artifact is the computer and this shows real signs of a burgeoning inner complexity something akin to the increase in complexity of the chemicals in our original primordial pool which gave rise to biological life, or the increasing complexity of neuronal networks in the pool of human minds which gave rise to mental life. New life in a pool of interconnected electronic "minds" is a real possibility. Life then could be seen as a series of levels, each in turn invaded by, or giving rise to, new life forms.

7. Bibliography

Adamson, D.A. and M.D. Fox, 1981, Change in Australian Vegetation since European Settlement, in J.M.B. Smith (ed.), *A History of Australian Vegetation*, McGraw-Hill, Sydney, pp. 109-146.

Adamson, G., 1968, *Bwana Game*, Collins, London.

Alekseev, V.P., 1992, Some Aspects of Paleological Studies, *Homo*, 43(2):123-134.

Asmussen, M.A. and A. Schnabel, 1991, Comparative Effects of Pollen and Seed Migration on the Cytonuclear Structure of Plant Populations. 1. Maternal Cytoplasmic Inheritance, *Genetics*, 128:639-654.

Aughterson, W.V., J. Aughterson and G.M. Stirling, 1952, *A Handbook of English*, Witcombe and Tombs, Melbourne.

Axelrod, R., 1984, *The Evolution of Cooperation*, Basic Books, New York.

Ayala, F.J., 1987, The Biological Roots of Morality, *Biology and Philosophy*, 1:235-252.

Ball, J.A., 1984, Memes as Replicators, *Ethology and Sociobiology*, 5:145-161.

Barrass, R., 1974, *The Locust*, Barry Shurlock, Winchester, Hants.

Bateson, P., 1989, Does Evolutionary Biology Contribute to Ethics?, *Biology and Philosophy*, 4:287-301.

Batterman, W.B., 1993, Defining Chaos, *Philosophy of Science*, 60:43-66.

Behera, N., and Nanjundiah, V., 1995, An Investigation into the Role of Phenotypic Plasticity in Evolution, *Journal of Theoretical Biology*, 172(3):225-234.

Bergland, R., 1985, *The Fabric of Mind*, Penguin, Melbourne.

Bischof, N., 1978, On the Phylogeny of Human Morality, in G.S. Stent (ed.), *Morality as a Biological Phenomenon*, Abakon Verlagsgesellschaft, Berlin, pp. 53-73.

Black, A., 1990, Jonestown - Two Faces of Suicide: A Durkheimian Analysis. *Suicide and Life-Threatening Behavior*, 20(4):285-306.

Boag, P.T. and P.R. Grant, 1982, Intense Natural Selection in a Population of Darwin's Finches (*Geospizinae*) in the Galapagos, in J. Maynard Smith (ed.), *Evolution Now*, W.H. Freeman, London, pp. 175-181.

Bookchin, M., 1986, *Toward an Ecological Society*, Black Rose, Toronto.

Boyd, R. and P.J. Richerson, 1985, *Culture and the Evolutionary Process*, University of Chicago, Chicago.

Brandon, R., 1985, Adaptation Explanations: Are Adaptations for the Good of Replicators of Interactors, in D.J. Depew and B.H. Weber (eds.), *Evolution at a Crossroads*, Bradford Books, London, pp. 81-96.

Byerly, H.C. and R.E. Michod, 1991, Fitness and Evolutionary Adaptation, *Biology and Philosophy*, 6:1-22.

Callicott, J.B., 1992, Can a Theory of Moral Sentiments Support a Genuinely Normative Environmental Ethic?, *Inquiry*, 35:183-98.

Calvin, M., 1969, *Chemical Evolution*, Oxford University Press, London.

Campbell, D.T., 1960, Blind Variation and Selective Retention in Creative Thought as in Other Knowledge Processes, in G. Radnitzky and W.W. Bartley (eds.), *Evolutionary Epistemology, Theory of Rationality and the Sociology of Knowledge*, Open Court, LaSalle, Il., pp. 91-114.

Campbell, D.T., 1974, Evolutionary Epistemology in P.A. Schlipp (ed.), *The Philosophy of Karl Popper*, Open Court, La Salle, pp. 413-463.

Campbell, D.T., 1978, Social Morality Norms as Evidence of Conflict Between Biological Human Nature and Social Systems Requirements, in G.S. Stent (ed.), *Morality as a Biological Phenomenon*, Abakon Verlagsgesellschaft, Berlin, pp. 75-92.

Campbell, D.T., 1991, A Naturalistic Theory of Archaic Moral Orders, *Zygon* 26:91-114.

Campbell, J., 1988, *The Inner Reaches of Outer Space*, Harper and Row, New York.

Campbell, J.H., 1985, An Organizational Interpretation of Evolution, in D.J. Depew and B.H. Weber (eds.), *Evolution at a Crossroads*, Bradford Books, London, pp. 133-167.

Cavalli-sforza, L.L. and M.W. Feldman, 1981, *Cultural Transmission and Evolution: a Quantitative Approach*, Princeton, New Jersey.

Chittka, L. and K. Greiger, 1995, Can Honey Bees Count Land Marks, *Animal Behaviour*, 49:159-164.

Christensen, P.E. and N.D. Burrows, 1986, Fire: An Old Tool with a New Use, in R.H. Groves, and J.J. Burdon (eds.), *Ecology of Biological Invasions: An Australian Perspective*, Australian Academy of Science, Canberra, pp. 97-105.

Chomsky, N., 1975, *Reflections on Language*, Random House, London

Collier, J., 1986, Entropy in Evolution, *Biology and Philosophy*, 1:5-24.

Coppinger R., J. Glendinning, E. Torop, C. Mattay, M. Sutherland and C. Smith, 1987, Degree of Behavioral Neoteny Differentiates Canid Polymorphs, *Ethology*, 75:89-108.

Corbett, L.K., 1988, Social Dynamics of a Captive Dingo Pack: Population Regulation by Dominant Female Infanticide, *Ethology*, 78:177-198.

Coveney, P., 1990, Chaos, Entropy and the Arrow of Time, *New Scientist*, 29:39-42.

Creel, S. and N. M. Creel, 1995, Communal Hunting and Pack Size in African Wild Dogs, *Lycan pictus, Animal Behaviour*, 50:1325-1339.

Csanyi, V. and A. Doka, 1993, Learning Interaction Between Prey and Predator Fish, in F.A. Huntingford and P. Torricelli (eds.), *Behavioural Ecology of Fishes*, Harwood Academic Pub., Chur, Switzerland. pp. 63-78.

Csikszentmihalyi, M., 1991, Consciousness for the Twenty-First Century, *Zygon*, 26:7-25.

Csikszentmihalyi, M., 1993, *The Evolving Self*, Harper/Collins, New York.

Darwin, C., [1859], 1968, *The Origin of Species*, Penguin, Victoria.

Dawkins, R., 1976, *The Selfish Gene*, Paladin Books, London.

Dawkins, R., 1982, *The Extended Phenotype*, W. H. Freeman, Oxford.

Dawkins, R., 1986, *The Blind Watchmaker*, Penguin, Ringwood, Victoria.

Dawkins, R., 1995, *River Out of Eden*, Weidenfeld and Nicolson, London.

Day, T., Pritchard, J., and Schluter D., 1994, A Comparison of Two Sticklebacks. *Evolution* 48(5):1723-1734.

DeAngelo, M.J., V.M. Kish and S.A. Kolmes, 1990, Altruism, Selfishness, and Hetrocytosis in Cellular Slime Moulds, *Ethology Ecology & Evolution*, 2:439-443.

Delbruck, M., 1986, *Mind from Matter*, Blackwell Scientific Publications, Oxford.

DeNault, L.K., and McFarlane, D.A., 1995, Reciprocal Altruism Between Male Vampire Bats, *Desmodus rotundus. Animal behaviour* 49:855-856.

Dennett, D.C., 1990, Memes and the Exploitation of Imagination, *The Journal of Aesthetics and Art Criticism*, 48(2):127-135.

Dennett, D.C., 1991, *Consciousness Explained*, Little Brown and Company, London.

Dennett, D.C., 1995, *Darwin's Dangerous Idea*, Simon & Schuster, London.

Denton, D., 1993, *The Pinnacle of Life*, Allen and Unwin, Sydney.

Dobzhansky, T., 1970, *Genetics of the Evolutionary Process*, Columbia University Press, New York.

Dobzhansky, T., F.J. Ayala, G.L. Stebbins and J.W. Valentine, 1977, *Evolution*, W.H. Freeman, San Francisco.

Doolittle, W.F. and C. Sapienza, 1982, Selfish Genes, the Phenotype Paradigm and Genome Evolution, in J. Maynard Smith (ed.), *Evolution Now*, W.H. Freeman, London, pp. 58-65.

Dukas, R. and L.A. Real, 1993, Effects of Recent Experience on Foraging Decisions by Bumble Bees, *Oecologia*, 94:244-246.

Durham, W.H., 1991, *Coevolution: Genes, Culture & Human Diversity*, Standford University Press, Standford.

Eldredge, N. and S.J. Gould, 1972, Punctuated Equilibria: An Alternative to Phyletic Gradualism, in T.J.M. Schopf (ed.), *Models in Palaeobiology*, Freeman, San Francisco, pp. 81-115.

Feibleman, J.K., 1965, Artifactualism, *Philosophy and Phenomenological Research*, 25:554-559.

FitzGerald, G.J., 1991, Egg Cannibalism by Sticklebacks: Spite or Selfishness?, *Behavioural Ecological Sociobiology*, 30:201-206.

Flew, A., (ed.), 1979, *Dictionary of Philosophy*, Pan, London.

Ford, J., 1989, What is Chaos that We Should be Mindful of it?, in P. Davis (ed.), *The new Physics*, Cambridge University Press, Cambridge, pp. 348-372.

Fox, L.R., 1975, Cannibalism in Natural Populations, *Annual review of Ecology and Systems*, 6:87-106.

Fox, W., 1990, *Toward a Transpersonal Ecology*, Shambala, Boston.

Fridlund, A.J., 1991, Evolution and Facial Action in Reflex, Social Motive, and Paralanguage, *Biological Psychology*, 32:3-100.

Futuyma, D.J. and M. Slatkin (eds.), 1983, *Coevolution*, Sinauer Associates, Sunderland, Massachusetts.

Gallagher, K.T., 1989, Natural Selection: A Tautology?, *International Philosophy Quarter*, 29:17-31.

Godard, R., 1993, Tit for Tat Among Neighbouring Hooded Warblers, *Behavioural Ecology and Sociobiology*, 33:43-56.

Goodenough, O.R., 1995, Mind Viruses: Culture, Evolution, and the Puzzle of Altruism, *Social Science Information* 24(2):287-320.

Goodenough, O.R. and R. Dawkins, 1994, The 'St Jude' Mind Virus, *Nature*, 371:23-24.

Gould S.J., 1980, Is a New General Theory of Evolution Emerging?, *Paleobiology*, 6:119-130.

Gould, S.J. and N. Eldredge, 1977, Punctuated Equilibria: The Tempo and Mode of Evolution Reconsidered, *Paleobiology*, 3:115-151.

Gould, S.J. and E.S. Vrba, 1982, Exaptation - a Missing Term in the Science of Form, *Paleobiology*, 8:4-15.

Grainger, A., 1982, *How People Make Deserts, How People can Stop and Why They Don't*, International Institute for Environment and Development, London.

Grant, G., 1986, Philosophy and Culture: Perspectives for the Future, in V. Cauchy (ed.), *Evolution and Culture*, University of Montreal, Montreal, pp. 172-182.

Grantham, T., 1992, Does Science Have a 'Global Goal?': A Critique of Hull's View of Conceptual Progress, *Biology and Philosophy*, 9:85-94.

Gray, R., 1992, Death of the Gene: Developmental Systems Fight Back, in P. Griffiths (ed.), *Trees of Life*, Kluwer Academic Publishers, Amsterdam, pp. 165-209.

Gribben, J., 1990, The Man who Proved Einstein was Wrong, *New Scientist*, 24:33-35.

Griffiths, P.E., 1992, Adaptive Explanation and the Concept of a Vestige, in P.E. Griffiths (ed.), *Trees of Life*, Kluwer Academic Publishers, Amsterdam, pp. 111-131.

Griffiths, P.E. and R.D. Gray, 1993, Developmental Systems and Evolutionary Explanation, Philosophy Department, University of Otago, Dunedin, unpublished.

Grim P., 1996, Spatialization and Greater Generosity in the Stochastic Prisoner's Dilemma, Biosystems, 37:3-17.

Groves, R.H., 1977, Fire and Nutrients in the Management of Australian Vegetation, in H.A. Mooney and C.E. Conrad (eds.), *Proceedings on the Environmental Consequences of Fire and Fuel Management in Mediterranean Ecosystems*, U.S. Department of Agriculture, Washington, D.C., pp. 220-229.

Hahlweg, K., 1991, On the Notion of Evolutionary Progress, *Philosophy of Science*, 58:436-451.

Hailman, J.P., 1982, Evolution and Behaviour: an Iconoclastic View, in H.C. Plotkin, *Learning, Development and Culture*, John Wiley & Sons, Brisbane, pp. 205-272.

Haji, I., 1992, Evolution, Altruism and the Prisoner's Dilemma, *Biology and Philosophy*, 8:161-175.

Halpike, C.R., 1986, *The Piniciples of Social Evolution*, Claredon Press, Oxford.

Hamilton, W.D., 1964, The Genetic Theory of Social Behaviour (I & II), *Journal of Theoretical Biology*, 7:1-32.

Hanbury-Tenison, R., 1990, No Surrender in Sarawak, *New Scientist*, Dec:12-13.

Harcourt, A.H., P.H. Harvey, S.G. Larson and R.V. Short, 1982, Testis Weight, Body Weight and Breeding Systems in Primates, in J. Maynard Smith (ed.), *Evolution Now*, W.H. Freeman, London, pp. 225-233.

Hardy, A.C., 1959, Escape from Specialization, in G.W. Leeper (ed.), *The Evolution of Living Organisms*, Melbourne University Press, Melbourne., pp. 122-142.

Harrer, H., 1955, *Seven Years in Tibet*, Reprint Society, London.

Hefner, P., 1991, Myth and Morality: the Love Command, *Zygon*, 26(1):115-135.

Hilson, J.A., S.A. Kolmes and L.F. Nellis, 1994, Fruiting Body Architecture, Spore Capsuale Contents, Selfishness, and Hetrocytosis in the Cellular Slime Mold Dictyostelium discoideum, *Ethology Ecology & Evolution*, 6:(in print).

Hill, D.P. and S.G. Sealy, 1994, Desertion of nests parasitiszed by cowbirds: have clay-colored sparrows evolved an anti-parasite defence?, *Animal Behaviour*, 48:1063-1070.

Hines, W.G.S., 1977, Competition with an Evolutionary Stable Strategy, *Journal of Theoretical Biology*, 67:141-153.

Ho, M. and P.T. Saunders (eds.), 1984, *Beyond Neo-Darwinism*, Academic Press, London.

Hoerr, W. 1993a, The Concept of Naturalness in Environmental Discourse, *Natural Areas Journal*, 13:29-32.

Hoerr, W., 1993b, Economics and Fossil Fuel Dependency: A Biological Analogy, *The Trumpeter*, 10:32.

Hoerr, W., 1996, Are Artifacts Living?, *Evolution and Cognition*, 2(1):80-86.

Hooker, C.A., 1994, Regulatory Constructivism: on the Relation Between Evolutionary Epistemology and Piaget's Genetic Epistemology, *Biology and Philosophy*, 9:197-244

Horton, D.R., 1984, Red Kangaroos: Last of the Australian Megafauna, in P.S. Martin and R.G. Klein (eds.), *Quaternary Extinctions*, The University of Arizona Press, Tucson, Arizona, pp. 639-680.

House, A., 1993, *The Great Safari*, Harper Collins, London.

Hull, D.L., 1985, *Science as a Process*, University of Chicago Press, Chicago.

Huntingford, F.A. and P.J. Wright, 1993, The Development of Adaptive Variation in Predator Avoidence in Freshwater Fishes, in F.A. Huntingford and P. Torricelli (eds.), *Behavioural Ecology of Fishes*, Harwood Academic Pub., Chur, Switzerland. pp. 45-62.

Hurst, L.D., 1991, The Incidences and Evolution of Cytoplasmic Male Killers, *Proceedings of the Royal Society of London*, 244:91-99.

Huxley, J., 1961, The Humanist Frame, in J. Huxley (ed.), *The Humanist Frame*, George Allen & Unwin, London, pp. 13-48.

Huxley, J., 1964, *Essays of a Humanist*, Penguin, Ringwood, Victoria.

Irons, W., 1991, How did Morality Evolve, *Zygon*, 26(1):49-89.

Jachmann H., P.S.M. Berry and H. Imae, 1995, Tusklessness in African Elephants: a Future Trend, *African Journal of Ecology*, 33:230-235.

Jackson, H.C., 1954, *Sudan Days and Ways*, Macmillian, London.

James, E.O., 1962, *Sacrifice and Sacrament*, Thames and Hudson, London.

Jeffery, J., 1990, Dirty Tricks: How the Nuclear Lobby Stopped the Development of Wave Power in Britain, *The Ecologist*, 20(3):85-90.

Johnston, L., 1992, An Ecological Approach to Biosystem Thermodynamics, *Biology and Philosophy*, 7:35-60.

Johnston, K.L., 1994, Evidence for Batesian Mimicry in a Butterfly-Polinated Orchid, *Biological Journal of the Linnean Society*, 53:91-104.

Jones, J.S., 1981, Models of Speciation - the Evidence from *Drosophila*, *Nature*, 289:743-744.

Kantorovich, A., 1989, A Genotype-Phenotype Model for the Growth of Theories and the Selection Cycle in Science, in K. Hahlweg and C.A. Hooker (eds.), *Issues in Evolutionary Epistemology*, State University of New York, Albany, New York, pp. 171-184.

Kary, C.E., 1990, One Causal Mechanism in Evolution: One Unit of Selection, *Philosophy of Science*, 57:290-296

Keller, E.F., 1987, Reproduction and the Central Project of Evolution Theory, *Biology and Philosophy*, 2:383-396.

Kellogg, D.E., 1988, "And then a Miracle Occurs" - Weak Links in the Chain of Argument from Punctuation to Hierarchy, *Biology and Philosophy*, 3:3-28.

Kettlewell, H.B.D., 1955, Section Experiments on Industrial Melanism in the *Lepidoptera*, *Heredity*, 9:323-342.

Kimura, M., 1984, *The Neutral Theory of Molecular Evolution*, Cambridge University Press, Cambridge.

Kitcher, P., 1993, The Evolution of Human Altruism, *The Journal of Philosophy*, 90(10):497-516.

Kolata, G., 1986, What Does it Mean to be Random?, *Science*, 231:1068-1070.

Krains D. and V. Krains, 1993, Learning to Cooperate with Pavlov; An Adaptive Strategy for the Iterated Prisoner's Dilemma with Noise, *Theory and Decision*, 35:107-150.

Kuhn, T.S., 1970, *The Structure of Scientific Revolutions*, University of Chicago Press, Chicago.

Kummer, H., 1978, Analogs of Morality Among Nonhuman Primates, in G.S. Stent (ed.), *Morality as a Biological Phenomenon*, Abakon Verlagsgesellschaft, Berlin, pp. 35-52.

Lange, R. and R. Purdie, 1976, Western Myall (*Acacia sowdenii*), its Survival Prospects and Management Needs, *Australian Rangeland Journal*, 1:64-69.

Lapie, P.O., 1943, *My Travels Through Chad*, John Murray, London.

Laylor, L.R and J. Maynard Smith, 1976, The Coevolution and Stability of Competing Species, *American Naturalist*, 110:79-99.

Leakey, R., 1994, *The Origin of Humankind*, Phoenix, London.

Lewin, R., 1980, Evolutionary Theory Under Fire, *Science*, 201:883-887.

Lewontin, R.C., 1978, Organism and Environment, in H.C. Plotkin (ed.), *Learning, Development and Culture*, John Wiley & Sons, Brisbane, pp. 151-171.

Lima-de-Faria, A., 1988, *Evolution Without Selection*, Elsevier, London.

Lindauer, L., 1961, *Communication Among Social Bees*, Harvard University Press, Massachusetts.

Losonsky, M., 1990, The Nature of Artifacts, *Philosophy*, 65:81-88

Lorenz, K., 1952, *King Solomon's Ring*, Methuen, London.

Lorenz, K., 1966, *On Aggression*, Methuen, London.

Lorenz, K., 1977, *Behind the Mirror*, Methuen, London.

Lotem, A.H., 1993, Learning to Recognize Nestlings is Maladaptive rot Cuckoo Cuculus Canorus Hosts, *Nature*, 362:743-745.

Lotem, A.,H. Nakamura and A. Zahavi, 1995, Constraints on Egg Discrimination and Cuckoo-Host Co-Evolution, *Animal Behaviour*, 49:1185-1209.

Lumsden, C.J. and E.O. Wilson, 1981, *Genes, Mind, and Culture*, Harvard University Press, Cambridge, Mass.

McKaye, K.R., 1977, Defense of a Predator's Young by a Herbivorous Fish: An Unusual Strategy, *The American Naturalist*, 111:301-315.

McKaye, K.R., 1986, Trophic eggs and Parental Foraging for Young by the Catfish Barrus meridioalis of Lake Malawi, *Oecologia*, 69:367-369.

McKaye, K.R. and N.M. McKaye, 1977, Communal Care and Kidnapping of Young by Parental Cichlids, *Evolution*, 31:674-681.

McKusick, V.A., 1990, *Mendelian Inheritance in Man*, John Hopkins University Press, Baltimore.

McShea, D.W., 1991, Complexity and Evolution: What Everyone Knows, *Biology and Philosophy*, 6:303-324.

Magurran, A.E. and A. Higham, 1988, Information Transfer Across Fish Shoals Under Predator Threat, *Ethology*, 78:153-158.

Malthus, T.R., [1798], 1966, *First Essay on Population*, Macmillian, London.

Mandelbrot, B., 1990, Fractuals - A Geometry of Nature, *New scientist*, Sept:22-27.

Marasis, E.N., 1971, *The Sole of the White Ant*, Cape and Blond, London.

Maser, C., 1990, On the Naturalness of Natural Areas: A Perspective for the Future, *Natural Areas Journal*, 10:129-133.

Mason, S.F., 1991, *Chemical Evolution*, Clarendon Press, Oxford.

Maugham, W.S., 1951, *Collected Short Stories, Vol.4*, Penguin, Melbourne.

Maynard Smith, J., 1968, *Mathematical Ideas in Biology*, Cambridge University Press, Cambridge.

Maynard Smith, J., 1974a, *Models in Ecology*, Cambridge University Press, Cambridge.

Maynard Smith, J., 1974b, The Theory of Games and The Evolution of Animal Conflicts, *Journal of Theoretical Biology*, 47:209-221.

Maynard Smith, J., 1978, The Concepts of Social Biology, in G.S. Stent (ed.), *Morality as a Biological Phenomenon*, Abakon Verlagsgesellschaft, Berlin, pp. 23-34.

Maynard Smith, J., 1981a, Macroevolution, *Nature*, 289:13-14.

Maynard Smith, J., 1981b, Symbolism and Chance, in J. Agassi and R.S. Cohen (eds.), *Scientific Philosophy Today*, D. Reidel, Amsterdam, pp. 201-206.

Maynard Smith, J., 1982b, *Evolution and the Theory of Games*, Cambridge University Press, Cambridge.

Maynard Smith, J., 1989, How to Model Evolution, in J. Dupre (ed.), *The Latest of the Best*, MIT Press, Cambridge, Mass., pp. 119-131.

Maynard Smith, J., 1993a, *Did Darwin Get it Right?*, Penguin, London.

Maynard Smith, J., 1993b, *The Theory of Evolution*, Cambridge University Press, Cambridge.

Maynard Smith, J. and G.R. Price, 1973, The Logic of Animal Conflict, *Nature*, 246:15-18.

Mayr, E., 1985, How Biology Differs from the Physical Sciences, in D.J. Depew and B.H. Weber (eds.), *Evolution at a Crossroads*, Bradford Books, London, pp. 43-63.

Meinig, D.W., 1970, *On the Margins of the Good Earth: The South Australian Wheat Frontier, 1869-1884*, Rigby Limited, Sydney.

Mills, S. and J. Beatty, 1984, The Propensity Interpretation of Fitness, in E. Sober (ed.), *Conceptual Issues in Evolutionary Biology*, MIT Cambridge, Massachusetts, pp. 36-57.

Mitchell, S.D., 1987, Competing Units of Selection?: A Case of Symbiosis, *Philosophy of Science*, 54:351-367.

Moller A.P. and J.V. Briskie, 1995, Extra-pair Paternity, Sperm Competition and the Evolution of Testis Size in Birds, *Behavioural Ecology and Sociobiology*, 36:357-365.

Monod, J., 1971, *Chance and Necessity*, Alfred Knopf, New York.

Morse, S.S., 1992, Evolutionary Views of Viral Evolution: Toward an Evolutionary Biology of Viruses, *History of Philosophy and Life Sciences*, 14:215-248.

Newsome, A.E. and I.R. Noble, 1986, Ecological and Physiological Characters of Invading Species, in R.H. Groves and J.J. Burdon (eds.), *Ecology of Biological Invasions: An Australian Perspective*, Australian Academy of Science, pp. 1-20.

O'Hear, A., 1989, Evolution, Knowledge, and Self-consciousness, *Inquiry*, 32:127-50.

O'Connell, S.M. and G. Cowlishaw, 1994, Infanticide Avoidence, Sperm Competition and Mate Choice: the Function of copulation Calls in Female Baboons, *Animal Behaviour*, 48:687-694.

Orgel, L.E. and F.H.C. Crick, 1982, Selfish DNA: the Ultimate Parasite, in J. Maynard Smith (ed.), *Evolution Now*, W.H. Freeman, London, pp. 67-75.

Packer, C., 1982, Reciprocal Altruism in *Papio anubis*, in J. Maynard Smith (ed.), *Evolution Now*, W.H. Freeman, London, pp. 204-208.

Parrinder, G., 1961, *West African Religion*, Epworth, London.

Peressini, A., 1993, Generalizing Evolutionary Altruism, *Philosophy of Science*, 60:568-586.

Piaget, J., 1973, *The Child's Perception of the World*, Paladin, London.

Pooni, H.S., I. Kumar and G.S. Khush, 1992, A Comprehensive Model for Disomically Inherited Metrical Traits Expressed in Triploid Tissues, *Heredity*, 69:166-174.

Popper, K., 1959, *The Logic of Scientific Discovery*, Hutchinson, London.

Popper, K., 1972, *Objective Knowledge*, Oxford University Press, London.

Prigogine, I. and I. Stengers, 1984, *Order out of Chaos*, Bantam Books, New York.

Quinn, T.P. and C.A. Busak, 1985, Chemosensory Recognition of Siblings in Juvenile Coho Salmon, *Animal Behaviour*, 33:51-56.

Radnitzky, G., 1990, The Birth of Modern Science Out of the 'European Miracle' - Freedom as a Condition of Economic Success and Scientific Process, *South African Journal of Philosophy*, 9:59-67.

Resnik, D.B., 1989, Adaptionist Explanations, *Studies in History and Philosophy of Science*, 20:193-213.

Richards, J.A., F.W. Sears, M.R. Wehr and M.W. Zemansky, 1964, *Modern College Physics*, Addison-Wesley, London.

Richards, R.J., 1986, A Defense of Evolutionary Ethics, *Biology and Philosophy*, 1:265-293.

Ridley, M., 1980, Evolution and Gaps in the Fossil Record, *Nature*, 286:444-445.

Ridley, M., 1985, The Problems of Evolution, Oxford University Press, Oxford.

Ruse, M., 1973, *The Philosophy of Biology*, Hutchinson & Co, London.

Schnabel, A. and M.A. Asmussen, 1992, Comparative Effects of Pollen and Seed Migration on the Cytonuclear Structure of Plant Populations. II. Parental Cytoplasmic Inheritance, *Genetics*, 132:253-267

Schilchner, F. and N. Tennent, 1984, *Philosophy, Evolution and Human Nature*, Routledge and Kegan Paul, London.

Schweitzer, G., 1898 (vols. 1 & 2), *Emin Pasha, His Life and Work*, Archibald Constable and Co., London.

Schwemmler, W., 1989, *Symbiogenesis: A Macro-Mechanism of Evolution*, Walter de Gruyter, Berlin.

Sealy S.G., 1995, Burial of Cowbird Eggs by Parasitized Yellow Warblers: an Empirical and Experimental Study, *Animal Behaviour*, 49:877-889.

Settle, T., 1993, Fitness and Altruism, Traps for the Unwary, Bystander and Biologist Alike, *Biology and Philosophy*, 8:61-83.

Shalins, M.D., T.G Harding, D. Kaplan and E.R. Service, 1973, *Evolution and Culture*, University of Michigan Press, Michigan.

Shanahan, T., 1990, Evolution, Phenotypic Selection and the Units of Selection, *Philosophy of Science*, 57:210-225.

Shanahan, T., 1992, Selection, Drift, and the Aims of Evolutionary Theory, in P. Griffiths (ed.), *Trees of Life*, Kluwer Academic Publishers, Amsterdam, pp. 133-161.

Shanks, N., 1991, Quantum Mechanics and Determinism, *The Philosophical Quarterly*, 43(170):20-37.

Sheldrake, R., 1982, *A New Science of Life*, Houghton Mifflin Company, Boston.

Shepard, R.N., 1989, Evolution of a Mesh between Principles of the Mind and Regularities of the World, in J. Dupre (ed.), *The Latest of the Best*, MIT Press, Cambridge, Mass., pp. 251-275.

Sherman, P.W. 1982, Nepotism and the Evolution of Alarm Calls, in J. Maynard Smith (ed.), *Evolution Now*, W.H. Freeman, London, pp. 186-203.

Simons, G., 1983, *Are Computers Alive?*, The Harvester Press, Sussex.

Singer, M.C., C.D. Thomas and C. Parmesan, 1993, Rapid Human-induced Evolution of Insect-host Association, *Nature*, 366:681-683.

Singh, G., 1981, Environmental Upheaval, in J.M.B. Smith (ed.), *A History of Australian Vegetation*, McGraw-Hill, Sydney, pp. 90-108.

Smith, J.W., 1992, The recent case Against Physicalist Theories of Mind: A Review Essay, in D. Lamb (ed.), *New Horizons in the Philosophy of Science*, Ashgate Publishing Company, Vermont, pp. 49-65.

Smith, W.R., 1927, *Lectures on the Religions of the Semites*, A. & C. Black, London.

Sober, E., 1984, *The Nature of Selection*, Bradford Books, London

Soler, M., J.J. Soler, J.G. Martinez and A.P. Moller, 1995, Chick Recognition and Acceptance: a Weakness in Magpies Exploited by the Parasitized Yellow Warblers: an Empirical and Experimental Study, *Animal Behaviour*, 49:877-889.

Sollas, W.J., 1915, *Ancient Hunters*, Macmillan, London.

Speke, J.H., [1863], 1912, *Journal of the Discovery of the Nile*, J.M. Dent & Sons, London.

Stanley, S.M., 1979, *Macroevolution*, W.H. Freemann, San Francisco.

Stebbins, G.L. and F.J. Ayala, 1981, Is a New Evolutionary Synthesis Necessary, *Science*, 213:967-971.

Stebbins, G.L. and F.J. Ayala, 1985, The Evolution of Darwinism, *Scientific American*, 253(1):54-64

Stein, E. and P. Lipton, 1989, Where Guesses Come From: Evolutionary Epistemology and the Anomaly of Guided Variation, *Biology and Philosophy*, 4:33-56.

Sterelny, K., 1992, Punctuated Equilibrium and Macroevolution, in P. Griffiths (ed.), *Trees of Life*, Kluwer Academic Publishers, Amsterdam, pp. 41-61.

Sterelny, K., 1994, Science and Selection, *Biology and Philosophy*, 9:45-62.

Sterelny, K., K.C. Smith and M. Dickson, 1996, The Extended Replicator, *Biology and Philosophy*, 11:377-403.

Taborsky, R., 1984, Broodcare Helpers in the Cichlid Fish *Lamprologus Brichardi*: Their Costs and Benefits, *Animal Behaviour* 32:1236-1252.

Taylor P.D. and S.A. Frank, 1996, How to Make a Kin Selection Model, *Journal of Theoretical Biology*, 180:27-37.

Tennant, N., 1983, Evolutionary v. Evolved Ethics, *Philosophy*, 58:289-302.

Thomas, K., 1983, *Man and the Natural World*, Penguin, London.

Thompson, P., 1989, *The Structure of Biological Theories*, State University of New York Press, Albany, New York.

Thompson, J.D., 1991, Phenotypic Plasticity as a Component of Evolutionary Change, *Trends in Evolution*, 6(8):246-249.

Tinbergen, N., 1965, *Social Behaviour in Animals*, Methuen, London.

Trigg, R., 1984, The Sociobiological View of Man, *Philosophy*, supplement: 93-110.

Trivers, R.L., 1985, *Social Evolution*, Benjamin-Cummings, Menlo Park.

Tullock, G., 1990, The Economics of (Very) Primitive Societies, *Journal of Social and Biological Structures*, 13(2):151-162.

Vaidya, A.B., J. Morrisey, C.V. Plowe, D.C. Kaslow and T.E. Wellems, 1993, Unidirectional Dominance of Cytoplasmic Inheritance in Two Genetic Crosses of *Plasmodium falciparum*, *Molecular and Cellular Biology*, 13(12):7349-7357.

Van Valen, L.M., 1973, A New Evolutionary Law, *Evolutionary Theory*, 1:1-30.

Varner, G.E., 1990, Biological Functions and Biological Interests, *The Southern Journal of Philosophy*, XXV111(2):251-270.

Voltaire, [1747], 1961, *Candide, Zadig and Selected stories*, Cassell, London.

Voorzanger, B., 1994, Bioaltruism Reconsidered, *Biology and Philosophy*, 9:75-84.

Waddington, C.H., 1957, *The Strategy of the Genes*, George Allen & Unwin, London.

Waddington, C.H., 1961, The Human Animal, in J. Huxley (ed.), *The Humanist Frame*, George Allen & Unwin, London, pp. 65-80.

Ward, H., 1910, *A Voice from the Congo*, W. Heinemann, London.

Waters, C.K., 1986, Natural Selection Without Survival of the Fittest, *Biology and Philosophy*, 1:207-225.

Weber, B.H., D.J. Depew, C. Dyke, S.N. Salthe, E.D. Schneider, R.E. Ulanowicz and J.S. Wicken, 1989, Evolution in Thermodynamic Perspective: an Ecological Approach, *Biology and Philosophy*, 4:373-405.

Weeks, J.A., 1913, *Among Congo Cannibals*, Seely, Sevice and Co. London.

Wickner, R.B. 1994, [URE3] as an Altered URE2 Protein: Evidence for a Prion Analog in *Saccharomyces cerevisiae*, *Science*, 264:566-569.

Will, C., 1989, The Renaissance of General Relativity, in P. Davies (ed.), *The New Physics*, Cambridge University Press, Cambridge, pp. 7-33.

Wilson, D.S., 1992, On the Relationship Between Evolutionary and Psychological Definitions of Altruism and Selfishness, *Biology and Philosophy*, 7:61-68.

Williams, G.C., 1966, *Adaptation and Natural Selection*, Princeton University Press, New Jersey.

Williams R., 1988, *Keywords*, Fontana, London.

Woodhouse, M.B., 1992, Philosophy and Frontier Science: Is There a New Paradigm in the Making?, in D. Lamb (ed.), *New Horizons in the Philosophy of Science*, Ashgate, Vermont, pp. 26-48.

Wuketits, F.M., 1988, Darwinism: Still a Challenge to Philosophy, *Zygon*, 23(24):455-467.

Young, J.Z., 1962, *The Life of the Vertebrates*, Oxford University Press, Oxford.