The Selfish Gene
(1987)
Richard Dawkins

1.Why are People?

"Today the theory of evolution is about as much open to doubt as the theory that the earth goes around the sun, but the full implications of Darwins revolution have yet to be widely realised." Pg 1.

"My purpose is to examine the biology of selfishness and altruism." …. "I am not advocating a morality based on evolution." …. " it is not an advocacy of one position or the other on the nature/nurture controversy." ….. "is not a descriptive account of the detailed behaviour of man or of any other particular animal species."

"An entity … is said to be altruistic if it behaves in such a way as to increase another such entities welfare at the expense of its own. Selfish behaviour has exactly the opposite effect." Pg 4. These definitions are behavioural not subjective.

Group selection theory holds little support with professionals but its intuitive appeal extends its sentience.

2.The Replicators.

"Darwin's 'survival of the fittest' is really a special case of a more general laws of survival of the stable." Pg 12

If the likely components of early earth, water, carbon dioxide, methane and ammonia are put in a flask and stimulated with UV light or sparks then amino-acids form.

At some point a replicator was made from these amino-acid building blocks. The replicators that were stable were those in that the individual molecules lasted a long time, or they replicated rapidly, or they replicated accurately.

"… a word like living does not mean it necessarily has to refer to something definite in the real world. Whether we call the early replicators living or not, they were the ancestors of life; they were our founding fathers." Pg 17

"The replicators that survived were those that built survival machines for themselves to live in." pg 18.

3.Immortal coils.

Proteins are long chains of amino-acids. DNA indirectly supervises the manufacture of proteins.

A DNA molecule is a long chain of nucleotides. A Human DNA molecule is split out into 23 pairs of chromosomes which are fully replicated in normal mitosis cell division. During the production of sperm and egg cells the meiosis cell division results in only 23 chromosomes but these are each a unique combination of the available chromosome material constructed in a process called crossing over. Other sources of variation are point mutations (copy error) and inversion (a piece of chromosome detaches, inverts and reattaches in the original position).

"The first thing to grasp about a modern replicator is that it is highly gregarious. A survival machine is a vehicle containing not just one gene but many thousands. The manufacture of a body is a cooperative venture of such intricacy that it is almost impossible to disentangle the contribution of one gene from that of another." Pg 24

"A gene may be defines as any portion of chromosomal material that potentially lasts for enough generations to serve as a unit of natural selection." Pg 28

"The shorter a gene unit is, the less likely it is to be split by any one crossing-over." Pg 29.

"The life span of a chromosome is one generation." Pg 30

"A gene is not indivisible, but it is seldom divided." Pg 34

"Genes are competing directly with their alleles for survival, since their alleles in the gene pool are rivals for their slot on the chromosomes of future generations." Pg 36 "…but other genes are just part of the environment" pg 37.

"A gene that is lethal in an older body may still be successful in the gene pool, provided its lethal effect does not show itself until after the body has had time to to do at least some reproducing." Pg 41

Two ways to extend the average life span 1. have children at a progressively later stage in life & 2. simulate the superficial chemical properties of a young body to prevent the turning on of late acting deleterious genes.

"there is rather little distinction between growth and non-sexual reproduction…" pg 43 consider elm trees with suckers and female greenflies.

"…if crossing-over benefits a gene for crossing over, that is a sufficient explanation for the existence of crossing over." Pg 44 similar for sexual reproduction.

"The simplest way to explain the surplus DNA is to suppose that it is a parasite, or at best a harmless but useless passenger, hitching a ride in the survival machine created by the other DNA." Pg 45

4.The Gene Machine.

This chapter is about behaviour, specifically rapid movement.

Survival machines evolved into multicellular organisms which, when the environmental supply of amino-acids became scarce, learnt to use sunlight directly (plants) or indirectly by eating plants (animals) or other animals.

Bodies are colonies of genes rather than colonies of cells as central coordination of individual cells has become dominant.

Animals require a central nervous system constructed with neurons to coordinate movement based on information from memory and sense organs.

"one of the most striking properties of survival-machines behaviour is its apparent purposiveness." pg 50

Negative feedback is a critical control mechanism.

Genes are master rule programmers and policy setters - the organism makes the moment to moment decisions - much more quickly and adaptably than the genes can.

Genes built a capacity for prediction in a real world by building a capacity to learn.

Simulation is another powerful future predicting and selection technique. Consciousness appears to be a by-product of powerful simulation including self.

Genes can code for a behaviour - consider a honey bee with two genes which coordinate behaviour for uncapping and discarding infected eggs.

"If we wish to (it is not really necessary), we can regard signals such as the cheep call as having a meaning, or as carrying information." pg 63. We do not think of brightly coloured butterflies as lying about their edibility but... "It may well be that all animal communication contains an element of deception right from the start, because all animal interactions involve at least some conflict of interest." pg 65. But in a footnote written later after reconsideration "...most animal signals are best seen as neither informative or deceptive, but rather as manipulative." pg 282

5.Aggression: Stability and the Selfish Machine.

Members of the same species tend to compete very directly for gene survival resources from food through to mates. Members of different species compete less directly. So why don't members usually murder and eat other competing members of the species as a matter of course? Game theory!

"An evolutionary stable strategy or ESS is defined as a strategy which, if most members of the population adopt it, cannot be bettered by an alternative strategy. It is a subtle and important idea. Another way of putting it is to say that the best strategy for an individual depends on what the majority of the population are doing. Since the rest of the population consists of individuals, each one trying to maximise his own success, the only strategy that persists will be the one which, once evolved, cannot be bettered by any deviant individual." Pg 69

Symmetric contests involve only individuals who are in all important aspects identical. Asymmetric contests include the possibility that the individuals have important strengths and weaknesses. "Whenever there is strong asymmetry in a contest, ESS's are likely to be conditional strategies, dependent on the asymmetry." Pg 83.

Because particular genes must be complementary to the whole set, "The gene pool will become and evolutionary stable set of genes, defined as a gene pool that cannot be invaded by any new gene." Pg 86

6. Genesmanship.

The selfish DNA is not one strand but all the replicas. A gene might be able to assist replicas of itself sitting in other bodies, and this would appear as individual altruism.

Are there plausible ways in which genes might recognise copies of itself in other individuals? Yes, kin have a greater than average chance of sharing a gene. Hamilton showed that, for rare (ie new) genes in the population, the chance of two people share the same gene can be calculated and expressed as relatedness; parent/child=0.5, siblings=0.5, Rule of

thumb, identify the most recent common ancestor of two individuals, count the generational distance (gd) in steps up the tree and back down again, then calculate 0.5gd.

But there are other important considerations. The age of the individual (or actually their likelihood to reproduce) will for instance cause the apparent altruism between grandchildren to be stronger that that shown by grandchild to grandparent (both with relatedness of 0.25). The certainty in the relatedness will cause the apparent altruism from mother to child to be stronger than from father to child because the mother can be more certain than the father that she is a parent! Consider also racial tension and that this predicts that maternal grandparents will be more caring than paternal grandparents! Another factor is the genes capacity to help (ie a parent is generally better equipped to help their child than the other way around).

Genes cannot perform this calculation of relatedness, certainty in relation and reproductive chance, but will evolve towards the statistical value for the environment in which they live. "When a man throws a ball high in the air and catches it again, he behaves as if he has solved a set of differential equations in predicting the trajectory of the ball. He may neither know or care what a differential equation is, but this does not affect his skill with the ball." Pg 96. These calculations are in-fact far to simple; for instance they neglect the fact that I have just eaten and it does not make sense to share the food equally with my sister. Rather the genetic tendencies have evolved to model the calculation in the environment that the genes find themselves.

7. Family Planning.

Child bearing is a different gene function from child caring and to some extent they compete for resources.

Genes are more successful if people begin having children at an early age as it shortens the generation cycle.

"..uncontrolled birth rates are bound to lead to horribly increased death rates. It is hard to believe that this simple truth is not understood by those leaders who forbid their followers to use effective contraceptive methods. They express a preference for 'natural' methods of population limitation, and a natural method is exactly what they will get. It is called starvation." Pg 111.

"…for any given species, in any given environmental situation, there must be an optimal clutch size. …..each selfish individual chooses the clutch size that maximises the number of children she rears. ….. she has to strike a balance between bearing and caring. The total amount of food and other resources which an individual female, or a mated pair, can muster is the limiting factor determining the number of children they can rear. " pg 116-117.

" … we have abolished the family as a unit of economic self sufficiency, and substituted the state. ….. Contraception is sometimes attacked as 'unnatural'. SO it is, very unnatural. The trouble is, so is the welfare state….. But you cannot have an unnatural welfare state, unless you also have unnatural birth-control, otherwise the end result will be misery even greater than that which obtains in nature. The welfare state is perhaps the greatest altruistic system the animal kingdom has ever known. But any altruistic system is inherently unstable, because it is open to abuse by selfish individuals, ready to exploit it. Individual humans who have more children than they are capable of rearing are probably too ignorant in most cases to be accused of conscious malevolent exploitation. Powerful institutions and leaders who deliberately encourage them to do so seem to me less free from suspicion." Pg117-118.

Individuals who miss out on territory or the opportunity to reproduce do not continue to try until they drop as a waiting strategy is more successful.

Large, often noisy displays of population can be interpreted as each individual attempting to convince the others that there is over-population, and that a smaller clutch size is optimal, so that their offspring can get a larger share of the available resources.

8. Battle of the Generations.

Should a mother have favourites or should she be equally altruistic towards all her children?

Parental Investment (PI) is defined as 'any investment by the parent in an individual offspring that increases the offspring's chances of surviving (and hence reproductive success) at the cost of the parents ability to invest in the other offspring." Pg 124. Any individual has a total expected lifetime PI available. Hence, there is a tendency to abandon runts and wean children once they can survive alone.

Menopause can be explained as an older woman (less efficient at raising children with age) invest in grandchildren (relatedness = 0.25) once they can deliver twice the gene copies of her own children. Mens fertility trails of gradually, so investing in their

children is always superior to grandchildren.

A mother will wish to wean a child before the child will wish to be weaned (mothers investment in child vs child's investment in future siblings)

A mother may increase optimum clutch size by 1 and abandon the runt.

It pays for a child to attract a disproportionate amount of parents resource (self investment vs investment in siblings) by deception (ie screaming louder, looking weaker etc) and for mothers to detect deception.

9. Battle of the Sexes.

A female is defined as the sex with the larger sex cells. In reptiles and birds the egg provides nutrition to the embryo for a long period. Male and female may have evolved from isogamy (indistinguishable sexes) where the female contribution became increasingly nutritious for the embryo (honest strategy) while the male contribution became increasingly numerous and agile (exploitive strategy).

Regardless of the numerous male sex cells there remains a stable ESS which gravitates to an equal population ratio of sexes.

It is better for both the male and the female to have their partner invest more in the raising of the children. However, the female has initially invested more in the construction of the eggs nutritious resources, so it is less advantageous for her to abandon her investment.

One course of action available to an abandoned mother and child is to deceive another male to support the child (the fathers possible counter strategy is to enforce a long period of courtship and drive off other males during the period), abort the child (if very young) or raise the child as a single mother. There is an advantage to desert the relationship first and leave the partner “holding the baby” because the partner has a 50% investment in the genes.

There are a couple of strategies whereby a female can lower the chance of being deserted and these are very common in nature.

The domestic-bliss strategy sees the females choose to be either coy and demand a long courtship prior to copulation. The male must invest heavily during the period by building a nest etc making desertion and expensive proposition to woo another coy female. Loose females and philandering males in the population will move the balance somewhat. Again, deception (male) and detecting deception (female) pay a significant role. There is more paternal devotion in fish where the male spews the sex cells out into the water rather than into a female.

The he-man strategy sees females choosing males who are likely to father children with superior survival strategies (ie big muscles, long legs etc). These characteristics become attractive, and then self fulfilling – attractive to attractiveness sake – as the more attractive males will have a better chance of being selected for reproduction (rather than just survival).

It tends to be the males who develop attractive gaudy colourings and the female who stays drab (to avoid predators). Females tend to be more fussy about which males they copulate with (to avoid hybridisation). Females tend to avoid incest more strongly (father/daughter incest more common than sibling/sibling, more common than mother/son). Males are more promiscuous.

10. You scratch my back. I’ll ride on yours.

Many animals live in groups – occasionally of more than one species.

If an animal is hunted by a predator that attacks the nearest prey, then it is sensible, not only to be part of a group, but also not to be on the periphery of the group.

If an animal spots a predator then it is sensible to call out a warning to the group so that all members can take evasive action – ie keeping still and quiet or making for a tree as a group (so that the caller does not have to be alone)

Some gazelles actually taunt the lion by jumping very high – and suggesting that it is very fast so try to catch some-one else.

Kamakazi bees are a more interesting example because that attack a honey raider with almost certain death. But as it turns out, these social animals (bees, wasps, ants & not termites) have soldier and worker casts which are sterile. Hence they can only assist their genes by caring for the fertile members of the community. Social insects need to be considered as either carers or bearers.

Hymenoptera groups (wasps, ants & bees) have an unusual form of sex determination. The single queen goes on one mating flight and stores sperm

for her entire reproductive life. Unfertilised eggs become males with only one copy of the chromosomes (from the Queen) and is sterile. Fertilised egg become females, with a full double set of chromosomes, but development into a worker vs a Queen depends on the food she is provided with. A hymenopterian female has a relatedness to her sisters of ¾ which is higher than to her mother (1/2). This means that the queen prefers a 1:1 ratio between offspring sex but the workers prefer a 3:1 sister:brother ratio. 3:1 ratios are found in nests which indicates the workers are exploiting the queen rather than the other way around!

There is an advantage for ants to capture slaves from other ant colonies and this allows the queen to deliver a 1:1 sex ratio!

Several species of and and some African termites farm fungus – a symbiotic relationship between of two species.

The mitochondria in human cells provide the primary source of energy but mitochondria may in fact have originated as symbiotic bacteria. Viruses consist of pure strands of DNA surrounded by a protein jacket and they are parasites with an alternate transport mechanism to regular sexual reproduction.

“In practice it may be difficult to distinguish cases of genuine two-way mutual benefit from cases of one-sided exploitation.” Pg 183. Problems arise however when there is a delay between favour and repayment because the organism in dept may be tempted to cheat. “reciprocal altruism can evolve in species that are capable of recognising and remembering each other as individuals.” Pg 183.

“A long memory and a capacity for individual recognition are well developed in man. We might therefore expect reciprocal altruism to have played an important part in human evolution. Trivers goes so far to suggest that many of our psychological characteristics – envy, guilt, gratitude, sympathy etc – have been shaped by natural selection for improved ability to cheat, to detect cheats, and to avoid being thought to be a cheat.” Pg 187.

11. Memes: The new replicators.

Cultural transmission is rather like genetic transmission, and is not unique to man (bird song example)

Fundamental principal: All life evolves by the differential survival of replicating entities.

Meme is pronounced to rhyme with cream.

“Whenever new conditions arise in which a new kind of replicator can make copies of itself, the new replicators will tend to take over, and start a new kind of evolution of their own.” Pg 193

A meme, like a gene, is defined not as a fixed length item, but where items are closely linked then it it convenient to lump them together as a single meme. Memes do not (yet) compete as clearly with other memes as do genes operating with sexual reproduction operating with the alternate alleles on the chromosome. However, memes do “compete” for mind share and do act in concert with other compatible memes.

The God meme comes with many associated beliefs, doctrines, songs, music, prayers etc etc. The “faith” meme in religious doctrine is self perpetuating and supports the structural integrity of the whole religious meme by not just rejecting the need for evidence but attaching positive re-enforcement to “blind faith”. A meme for celibacy can survive in the gene pool as part of an ESS because it is replicated by words and influence rather than sperm. The set of religious memes are an ESS which makes it hard for them to be invaded by new memes.

“The meme complexes of Socraties, Leonardo, Copernicus, and Marconi are still going strong” pg 199 despite the complete dilution of their genes in the gene pool.

“Once the genes have provided their survival machines with brains that are capable of rapid imitation, the memes will automatically take over. EW do not even have to posit a genetic advantage in imitation, thought that would certainly help. All that is necessary is that the brain should be capable of imitation: memes will then evolve that will exploit that capability to the full.” Pg 200.

“We alone on earth, can rebel against the tyranny of the selfish replicators” pg 201 This is not a contradiction: contraception is just one such rebellion!

12. Nice Guys Finish First.

Reciprocal Altruism is an ESS

Prisoners Dilemma inevitably results in a poor outcome for both players as they have no way on ensuring cooperation. However a repeated game of prisoners dilemma offers various alternate strategies – that often degrade to the single game strategy.

Axelrod conducted a competition where he ran strategy submissions from 14 participants (an a random strategy) on a single computer environment where every strategy was pitted against every other (including itself) in each round for 200 rounds. The winning strategy was “tit for tat” which cooperated in the first round and then mirrored the opponents previous move after that.

Consider how “tit for tat” fairs against a couple of other strategies. “Naïve prober” is the same as “tit for tat” but throws in a random defection every 10 moves. “Remorseful prober” is the same as “naïve prober” except it when its random defection results in immediate retaliation, it allows the other player one free hit. “tit for tat” wins against both these strategies.

In Axelrods competition, the top 8 ranked strategies were nice (never the first to defect) and the other 7 nasty strategies (first to defect) trailed well behind. Forgiving strategies (which do not hold a grudge forever) also did well. If a “tit for two tats” were entered it would have won this first competition.

Axelrod's second tournament attracted 62 competitors (and random) and was run for unlimited rounds. “tit for tat” again won by an even stronger margin. All but one of the top 15 strategies were nice and all but one of the bottom 15 strategies were nasty. “tit for two tats” was submitted but did not win this second competition amongst more nasty strategies – some subtly designed to exploit “tit for two tats”.

“Tit for tat” turned out to be a robust strategy – but it would not have won within a high proportion of strategies. A ESS strategy must perform well against itself as it tends to become prolific.

Axelrod's third tournament used the same strategies but each winner was paid in “offspring” rather than points. Nasty strategies often had short term success. Tit for tat won five of six rounds. Tit for tat is not technically an ESS because it can be invaded by another nice strategy. “Always retaliate” is similarly stable and is an ESS. There is a critical point where the first to dominate of “tit for tat” and “Always retaliate” will stay dominant. Note that a stable strategy can slowly build in a local area and come to reach this critical point in the population as a while – this involves viscosity and edge effects. Note further that tit for tat” can prosper locally but “always retaliate” cannot because it does very poorly against itself. In this sense tit for tat has a higher order stability (over a longer time-frame” Axelrod assigns a third descriptor “non-envious” to strategies like tit for tat as it does not strive to have more than another (in point terms).

Many people assume games are zero-sum when they are not (consider the divorce process) – often to their detriment.

Players in the iterated Prisoners Dilemma must not know when the last round is because then they will play the last round as a single Prisoners Dilemma – whereby the second from last round will become the last round then …….

Examples from WWII trench warfare, wasps, and vampires.

13. The Long Reach of the Gene.

There is an uneasy tension between the gene and the highly complex and aware individual in the theory of the selfish gene.

The important differences between genes emerge as their effects – phenotypes.

Most gene examples are where the effect is good for the gene and good for the organism. There are examples where the gene is good for itself but not for the organism. In meiotic drive the gene creates a far greater chance than 50:50 of being selected in meiosis of the sex cells – and hence quickly spreads through the population. Often these effect are bad for the organism and result in extinction.

The extended phenotype is where the effects of the genes go beyond the organism to inanimate artefacts and the behaviours of other organisms ie to all the effects that it has on the world.

Caddis flies build themselves a shell from materials that they find on the river bed. (Why are we less impressed by this than if we discovered a dolphin doing the same thing??) The caddis house is an adaptation evolved from natural selection – it it therefore part of the phenotype just as an am or leg is. A lobsters shell is part of its body, so why not a caddis house?

The effects of genes are always indirect. The only thing that a gene affects directly is the building of proteins.

Snail genes affect the qualities of a snails shell – but snails have a parasite called a fluke that causes the snail to build a thicker shell. If the snail needed a thicker shell then it would have evolved one. The genes of the fluke are causing the snail to grow a thicker shell so that it lives longer but in doing so disturbs the balance that the snail has struck with the aim of reproducing the snails genes. Good for the fluke lifespan, and the snail lifespan but not

optimum for the snails genes reproduction.

However, when the parasite's genes are transmitted via the hosts genes (as for the ambrosia beetle and a bacterial parasite), both organisms could be expected to optimise the reproductive capacity of the host. In this instance the parasite will become progressively integrated into the hosts body.

Consider a virus induced cough or cold in humans. Both genes are interested in having the host sneeze – the host to expel the virus and the virus as a form of transport to the next host.

Beavers have a huge extended phenotype – dams! Cookoo nestlings must do more than simply have an egg which looks similar to the host because when the egg hatches the chick looks progressively different to the host chick. In this case the open mouth of the cookoo chick triggers a nervous reaction in the mother to put food in it. It has even been documented that host birds get distracted on their way back to their nest with a load of food and deviate to another nest and another cookoo chick altogether to put food in the gaping mouth. This is rather like an addiction (Consider pornography – how does a picture induce an erection). Why have the duped cookoo hosts not evolved a defence? Because it is an arms race and cookoo chicks have more to loose than the duped host!

"In one sense, all the genes in a body are 'parasitic' genes, whether we like to call them the body's 'own' genes or not." Pg250

The number of examples and development of examples in the insects almost always exceeds that of the rest of the animal kingdom. Some ants with 'cookoo' strategies actually take over the queen by using chemical means to get the queens worker ants to cut off the queens head. Caterpillars use a chemical mix to hire mercenary protective forces by making the ants more aggressive against everything but the caterpillar!

"Central Theorem of the Extended Phenotype: An animals behaviour tends to maximise survival of the 'genes' for that behaviour, whether or not those genes happen to be in the body of the particular animal performing it." Pg 253

It is best to use the words replicator and vehicle. Two replicators will merge when the vehicles are the same as they have complimentary goals (consider parasites, herds and bee colonies as examples).

Why did genes gang up and make large bodies for themselves to live in?

Why did genes gang up in cells? To create an local environment which concentrates resources and allows multi step chemical reactions. The complementary genes for each of the steps must me grouped together to achieve the outcome.

Why did cells gang up in many-celled bodies? Groups of cells have a size advantage and cells can specialise in complimentary roles.

Why did bodies adopt a bottle-necked life-cycle? A bottlenecked lifestyle refers to the generational growth of a new organism. Each generation offers the opportunity "to go back to the drawing board". Timing is introduced to allow very specific sequential growth of the complex organism. The bottleneck also ensures that (almost) all of the cells in the organism have the same genes and there ability to work together is tested as a whole organism competing against other organisms with a different set of genes.

"The two phenomena: discrete organisms and bottlenecked life-cycles go hand in hand." Pg 264

"Let me end with a brief manifesto, a summary of the entire selfish gene/extended phenotype view of life. It is a view, I maintain, that applies to living things everywhere in the universe. The fundamental unit, the prime mover of all life, is the replicator. A replicator is anything in the universe of which copies are made. Replicators come into existence, in the first place, by chance, by the random jostling of smaller particles. Once a replicator has come into existence it is capable of generating an indefinitely large set of copies of itself. No copying process is perfect, however, and the population of replicators comes to include varieties that differ from one another. Some of these varieties turn out to have lost the power of self-replication, and their kind ceases to exist when they themselves cease to exist. Others can still replicate, but less effectively. Yet other varieties happen to find themselves in possession of new tricks: they turn out to be even better self-replicators than their predecessors and contemporaries. It is their descendants that come to dominate the population. As time goes by, the world becomes filled with the most powerful and ingenious replicators.

Gradually, more and more elaborate ways of being a good replicator are discovered. Replicators survive, not only by virtue of their own intrinsic properties, but by virtue of their consequences on the world. These consequences can be quite indirect. All that is necessary is that eventually the consequences, however tortuous and indirect, feed back and affect the success of the replicator at getting itself copied.

The success that a replicator has in the world will depend on what kind of a world it is the pre-existing conditions. Among the most important of these conditions will be other replicators and their consequences. Like the English and German rowers, replicators that are mutually beneficial will come to predominate in each other's presence. At some point in the evolution of life on our earth, this ganging up of mutually compatible replicators began to be formalized in the creation of discrete vehicles-cells and, later, many-celled bodies. Vehicles that evolved a bottlenecked life cycle prospered, and became more discrete and vehicle-like.

This packaging of living material into discrete vehicles became such a salient and dominant feature that, when biologists arrived on the scene and started asking questions about life, their questions were mostly about vehicles-individual organisms. The individual organism came first in the biologist's consciousness, while the replicators - now known as genes - were seen as part of the machinery used by individual organisms. It requires a deliberate mental effort to turn biology the right way up again, and remind ourselves that the replicators come first, in importance as well as in history.

One way to remind ourselves is to reflect that, even today, not all the phenotypic effects of a gene are bound up in the individual body in which it sits. Certainly in principle, and also in fact, the gene reaches out through the individual body wall and manipulates objects in the world outside, some of them inanimate, some of them other living beings, some of them a long way away. With only a little imagination we can see the gene as sitting at the centre of a radiating web of extended phenotypic power. And an object in the world is the centre of a converging web of influences from many genes sitting in many organisms. The long reach of the gene knows no obvious boundaries. The whole world is criss-crossed with causal arrows joining genes to phenotypic effects, far and near.

It is an additional fact, too important in practice to be called incidental but not necessary enough in theory to be called inevitable, that these causal arrows have become bundled up. Replicators are no longer peppered freely through the sea; they are packaged in huge colonies - individual bodies. And phenotypic consequences, instead of being evenly distributed throughout the world, have in many cases congealed into those same bodies. But the individual body, so familiar to us on our planet, did not have to exist. The only kind of entity that has to exist in order for life to arise, anywhere in the universe, is the immortal replicator.” Pg 264

Further Reading
Dawkins, The extended phenotype.