The Selfish Gene Study Guide

The Selfish Gene by Richard Dawkins

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Plot Summary

According to the introduction to this book, "The Selfish Gene" changes the way that many scientists look at the process of natural selection. The author begins by suggesting that intelligent, thinking animals must ask questions about its origins, and that Darwin has supplied excellent answers. However, Darwin's thoughts have been misinterpreted over the years to suggest that animals work together to preserve their own species. This book will challenge that idea.

In the next chapter, Dawkins describes how the very earliest forms of life may have come to be. He says that when electrical energy combines with the sort of chemicals in early earth's seas the result is a sort of soup of the building blocks of life. If any of the molecules in this soup somehow begin to replicate—or make copies of themselves, the process of life would follow. The molecules that make the most accurate copies of themselves and which last the longest outnumber the others. When the raw material of building is used up, the molecules with protection or aggressive behaviors outnumber the others.

Next, the author uses the metaphor of a library to describe how chunks of DNA in the form of genes become instructions for building each living thing. A gene is a length of DNA protein chain instructions. Every cell in a plant or animal body contains the same instructions. These instructions originally are formed when half the instructions from a sperm and half from an egg come together to make a new creature. Some instructions are lost, others are passed down. The ones that don't get included in the instructions for building the new body are called alleles. The point is that the gene, which is made up of chromosomes of DNA, is the smallest most basic unit of life that could obey the rules of natural selection. But how can genes control the actions of living creatures and plants? The answer the author comes to is that there is no conscious control. Often an animal appears to be behaving a certain way because it has made a conscious choice, but more often it is operating according to long established rules. Like a computer playing chess, consciousness is not necessary for an animal to engage in survival behavior.

Using advanced math and computer simulated games, the author shows why the most selfish survival tactic of any individual is not to directly attack others in its group even though they compete with him for food and mates. Risks like wasting time or being injured makes an "attack when attacked" attitude safest. Dawkins reminds readers that he is talking about the genes in one animal within a species. Related individuals carry a large percentage of the same genes, and this explains many acts of kindness between family members. The author shows a mathematical way to calculate how many genes various family members might share, and this seems to support the widely observed phenomena of parental care and altruism. Why not make an infinite number of copies of oneself? Sometimes limiting family size may be for the good of the individual gene, shows Dawkins, because the grown up carrier of the gene (parent) could not succeed under conditions of stress or famine and might itself die in the process.

In the following chapter the author examines why the selfish offspring does not try to trick the parent into stealing from brothers and sisters to gain more resources and care from the parents. Again, the offspring share genes with nest mates, so brothers and sisters satisfied with "just enough for all" will survive in greater numbers than totally selfish siblings.

Parents don't share genes, but do share an investment in offspring. A real war of the sexes picture is painted by the author as he suggests that it might be better for the gene machine to breed and then selfishly leave the other partner to raise the young while it goes off to breed again. But, using game theory, the author shows why this is not a stable strategy. The slight gain of staying together and successfully raising young (even if a little time is wasted in care and courtship) trumps the negatives of abandoning the other partner to raise the offspring alone and possibly fail.

The author talks about the origin of herds and flocks. Each individual gene machine has a lesser chance of being eaten by a stalking predator if it is wrapped in a group. It will naturally crowd closer into the center of a group, which explains how herds or flocks are formed. He discusses various behaviors that appear unselfish but may be selfishly oriented, and then goes on to talk about the weird world of bees, wherein the workers do not ever breed. This he explains by the fact of their reproductive methods. Because they don't follow normal rules of sexual reproduction, the sterile female workers are more closely related to one another than a parent and child. It behooves their common genes to support the queen mother as she makes up gobs of identical twin sisters for the colony. Finally, Dawkins shows how cooperation between animals of different species might have arisen.

A curious last chapter shows how ideas might spread using the same mechanisms as natural selection. He calls ideas memes and indicates that many ideas tend to repeat (copy themselves), have longevity, and spread. The author hopes that we, as thinking beings, can move beyond unexamined ideas which may have spread in this way to think more deeply and more altruistically—even though altruism isn't natural!

Chapter 1

Chapter 1 Summary and Analysis

The title of this chapter is supposed to sound like the sort of question children ask: "Why are people this way or that way?" But Dawkins wants to consider something even more basic. Why are people in existence at all? The author thinks that intelligent life must be life that asks where it came from. Also, he believes that it took three thousand million years and a man named Charles Darwin to come up with the correct answer to this question. Darwin is, of course, the thinker behind the concept of evolution, which is accepted by most scientists today.

Doubt about evolution, according to Dawkins, who is writing in 1976, is rare. However, he admits, philosophy classes and humanities don't often make use of the science of evolution. He is writing this book to examine the biology of selfishness and altruism, the latter a word meaning doing unselfish acts for another being.

Dawkins says that several people who have written books about human behavior have gotten it "wrong" because they don't understand that evolution is about the good of the individual gene, not evolution for the good of a species. Before going on to explain this, he makes a comparison. He says that if you met a gangster who had lived a long and prosperous life you would think he had been tough and selfish because he would have lived in a dangerous, competitive world. The types of plants and animals that survive for many generations in a dangerous competitive world must be selfish too.

On the other hand, Dawkins says he's going to talk about how sometimes an animal or plant with a certain gene can achieve a selfish goal by doing something kind or cooperative.

The author makes it very clear that he does not believe selfishness is a good thing. He would not like to live in a world where people behaved selfishly or were guided only by their biological urges. We should try to teach something other than our selfish natural tendencies, he believes.

In addition, although Dawkins is a zoologist, he does not believe that genetically inherited traits are impossible to change. This book is not about believing that either inherited traits (nature) or teaching (nurture) are more important in forming people's behavior, and although he has a private belief about this issue, he isn't planning to express that belief in this book.

Another point the author tries to make clear at the start is that we can never really know for sure if a behavior is selfish or just seems to be selfish. Therefore, he uses the word "apparently" a great deal in his book. The writer mentions several apparently selfish behaviors that might shock a reader. A kind of gull eats baby chicks out of different nests. The praying mantis eats her mate while they are mating. Penguins shove one another at the edge of a cliff to see which one will fall in first. Apparently unselfish behaviors include a bee losing its life to sting an intruder. Some small birds draw attention to themselves instead of the flock when a hawk comes by, and many mother animals do drastic things to protect their young. The author claims this book will show that both apparently selfish and unselfish—or altruistic—behaviors are still motivated by the selfishness of genes.

Again, he remarks that evolution does not do anything for the good of the species. The species just happens to do well if most of the individuals in it do well. This is kind of the opposite of the unscientific feeling that the "goal" of evolution is for species to survive and that a species in which individuals usually sacrifice themselves for the good of all will do well. That doesn't really happen, says Dawkins, because when even one selfish un-sacrificing member comes in or is born, it will take advantage of the unselfishness of others and over run the group with its own super-successful children.

Textbooks and famous scientists often use phrases like "to ensure the survival of the species". But the species can't see the future and doesn't have a group goal at all, says Dawkins.

Perhaps many people tend to like or believe the notion of group selection because it fits in with our social beliefs and current goals, such as asking people to go to war to protect their country. The author talks about how we tend to think of our species as somehow more important than others. We don't eat our own kind. Many think it is wrong to kill a brainless, unthinking fetus, but okay to kill an ape which can think and even be taught some language. Some think that this love for one's own species is natural. Dawkins does not say this thinking is right or wrong, just that it has nothing to do with evolutionary biology. If we begin to believe animals naturally show more concern for their own species than other species, why shouldn't they also have more concern for their own class or kingdom or phylum of animals? Wouldn't a lion be kinder to a mammal than to a reptile?

The author claims he will try to explain why sometimes an animal does something unselfish for the group, but in general he is trying to prove that the most basic unit of self protection is the gene.

So, what is a gene, anyway? The next chapter tells.

The overview presented here is in classical form, wherein it is traditional to tell an audience what you plan to say, then to go through and support your argument. Interestingly, the author takes a very informal, friendly, and common sense approach which is easy to understand and accept.

Chapter 2

Chapter 2 Summary and Analysis

It is tough to explain how things have developed from simple early beginnings to complex life, says the author, and he goes on to suggest that Darwin's idea of "survival of the fittest" might be better called "survival of the stable", because the world is full of things that last long enough to be the same for a while, such as salt crystals, mountains, and more. Also, things in our natural world tend to fall together into the most stable patterns, such as water molecules floating in space making round shapes. However, when smashed down by gravity and air, these round shapes become flat like a lake. Dawkins explains how chains of atoms in our blood link up to form amino acids that make up protein molecules that twist around into even bigger twisty tree-like molecules called hemoglobin. Millions of them are being made and destroyed in your body every second and they always form that way because it's the most natural, stable shape.

In ancient seas, says Dawkins, water carbon dioxide, methane, and ammonia existed and were hit by lightning. When scientists try to mix these simple elements in the lab and strike them with something like lightning (electricity), they consistently form a sort of soup full of more complicated amino acid molecules. Amino acids make protein, which makes up living things. Dawkins says if such large molecules formed naturally in ancient seas they would not have any enemies in the time before life so many of them could have floated around for a long while.

Somehow, one of these molecules at least was able to make copies of itself. Dawkins calls this the "Replicator". It sounds like an amazing accident, but Dawkins does not think it so statistically remarkable since there would have been billions and billions of chances over billions of years for one such freak molecule to come about. This replicator would only have to arise one time. It could easily collect or link onto other single molecules around it in the soup to stack up bigger and bigger, much in the way that crystals are formed by linking molecules in nature. It might then split apart to make new replicators. The author also images another possibility, wherein the replicator acts like a mold that other molecules are shaped into.

Here Dawkins starts to show how the rules of natural selection began to influence the earliest form of pre-life.

He says mistakes almost always happen when copies of things are made. And when copies of things with mistakes in them are made, this magnifies the original mistake. This, thinks Dawkins, is how new varieties of the replicator molecule came to be.

The replicator molecules that were the most stable would have had more time to make more copies of themselves. This is called "longevity", or long life, and it is an important part of theory of evolution in animals and plants. To be successful, a plant or animal needs sufficient longevity to have time to make copies of itself.

Eventually, the replicator molecules that made a lot of copies would start to over number the ones that made few copies. This is called "fecundity", or fertility, in the theory of evolution. Things that make a lot of copies of themselves have a greater chance of more of those copies surviving.

Finally, fidelity—or the ability to make copies just like itself—would mean more of a particular molecule would survive. But, on the other hand, mistakes do happen and do create new things. Is fidelity important to evolution? The answer is tricky, according to the author. Dawkins points out that things don't want to change and evolve. It just happens. The tendency by replicators (the early versions of genes) was to remain the same and keep churning out copies just like themselves. Sometimes a mistake happens. There is no good or bad about it.

Eventually, the things that are either stable longer or more productive or better at making an exact duplicate of themselves will outnumber other things which are not so successful. This is what happens today with plants and animals. This is an important part of the meaning of natural selection. So the story of the replicator sounds a lot like the story of natural selection.

The author says that it really doesn't matter if we say these replicators were "life" or not, because naming something does not change the reality of what it is and what it does.

The next important question the author addresses is why the other part of evolution came to be: competition. The writer believes that eventually the simple building block molecules must have been used up. Different varieties of replicators which had come to be because of messed up copying were more or less successful at linking up with and using up the simple building block type molecules. The less successful replicators would have been pushed aside or destroyed over time. And somewhere along the line, some replicator molecules became successful by breaking down the molecules of other replicator molecules and using their parts. These molecules would eventually become animals. Others molecules started to manufacture their own energy using solar power, and these became plants. The molecules which grouped to build protective walls around themselves became the first single celled organisms.

Things got bigger and more complicated. Dawkins says these things are plants, animals, bacteria, viruses and us, and that all life is just machines for protecting the competing replicators.

This chapter is the most difficult for the author to defend because, of course, so little information about the dawn of life exists. In general, though, it is one of the most clear and compelling description of the way life may have likely evolved available to the average reader. Interestingly, the idea calls for various leaps of faith, such as the belief in replicator molecules.

Chapter 3

Chapter 3 Summary and Analysis

There is no telling how many living things exist on earth, Dawkins claims. Of insects alone there may be a million million million. But even though plants and animals and viruses are all very different, they are basically made of the same molecule—DNA. The author says this points to the idea that all living things have come from the same sort of replicators which have found different ways to preserve their pattern or genes. There is no way to know if earth's DNA is different than the original replicators because no record of them exists.

DNA is a long series of tiny molecules called nucleotides, just like proteins are chains of amino acids. The DNA is made of two nucleotide chains, whether it's in a mouse, a bacteria, a human, or a tree. The reason the mouse, bacteria, and human turn out differently from one another is because DNA contains different instructions about how to build them.

Every cell has a copy of the creature or plant's DNA in it, which Dawkins says we can think of as being like a set of plans. Writing in the mid '70s, Dawkins already sees that scientists can describe the pattern of DNA in an individual using the letters ATCG, letters that stand for different types of nucleotides.

Here Dawkins creates a brilliant metaphor to explain what DNA is like. Unfortunately, the description is a bit confusing because he uses the terms chromosome, DNA, and gene in a way that isn't very specific. This is because scientists at the time seem unclear on the various roles of these things.

Pretend, Dawkins instructs, that there is a building with a giant bookcase and on the shelves are forty-six books. Each book has the plans for the whole building in it. This represents the forty-six chromosomes in every human cell.

The bookshelf is like the center of a cell, or the nucleus. Each book on the shelf can be compared to one chromosome. Each page of instructions in each book explaining part of the architecture is like a gene—although in the real world genes aren't separated neatly like pages are.

Before going on with this comparison, Dawkins points out that DNA isn't exactly like the blueprints for making a building because DNA is more like the plans for making different proteins that build a particular kind of body or plant. Genes which are sections of DNA must build successful cells or animals or plants in order to make copies of themselves.

This is done in cooperation with lots of other types of genes or DNA together in a single body. Some genes do some work, others do other types of work. And when sexual reproduction happens, some genes get discarded and others end up being duplicated in a large number of individuals over a long period of time.

There are forty-six pairs of chromosomes (books) in the human design, but it's better to think of this as twenty-three pairs of instructions—half from one parent, half from another—that come together when a sperm and egg meet. Randomly, "pages" (DNA) sections or genes) get torn out of one book—the sperm book. Other random parts are torn out of the egg book (egg) and are stuck together to make a whole new book: a human embryo cell. As long as each part comes from the right page number (the gene from dad's eyes instead of one from mom's eyes, for example, but not an eye gene for a liver gene) the person will get a full set of instructions in how to grow a body. Genes that aren't used are often kept and passed on to the offspring to possibly be used again. Two different genes that could fit in the same slot or page are called "alleles", but Dawkins says they could also be called rivals.

Next, when that human cell divides to make skin, bone, nerve and so on, an exact duplicate of all forty-six new genes goes with it. This is called mitosis.

On the other hand, "meiosis" is the making inside a person (or animal or plant) of a new chromosome egg or sperm cell. This is even stranger to Dawkins, because every single sperm or egg ends up with a slightly different mix of the "pages" and "parts of pages" (genes) from the pair which came down from both parents and which instructed the body how to make itself.

Swapping out parts of chromosomes is called "crossing over". Crossing over is why every sperm and egg in every person is different.

Now, enough with the pages/library metaphor, says the author. Things get more complicated here, because genes aren't really simple pages. They're chains of protein and the way we mark them is with symbols for "end of protein chain message" or "start of protein chain message". A gene which some call a cistron is the chunk in between the start and stop markers. Meiosis crossing over ignores the stop start messages. The process just matches and puts gene information in the right place. This is why Dawkins says you have to be kind of loose about defining the word "gene". He thinks we could call a gene something with at least part of a chromosom that lasts for a number of generations. Even if the larger chunk of gene changes, parts of it might live on in you or your father's other children, and so forth.

One way that genes change is "point mutation", where something goes wrong on a gene, like a misprint on a book, or "inversion", where a gene gets inserted backwards on the strand. This makes it possible for one variety of tasty butterfly to look like either one or another species of nasty tasting butterflies. By some wacky accident of inversion, a bunch of genes have made a new chromosome cluster, or "gene", that results in a wing pattern that looks like the nasty butterfly. Its allele is another cluster of chromosomes. These clusters tend to travel together on eggs and sperm for generations, so most often the butterfly is born with one not so tasty look, or the allele of other, and anything in between gets eaten by predators.

The author's point in talking about all this is that the gene is the smallest unit he can think of that can be said to engage in competition and natural selection. Everything bigger or more complex than these units get killed, torn apart, rearranged, and reworked. You have kids, but they will never be your exact copy of your genes. Genes don't get senile, and they last for millions of years as identical copies of themselves (although the original DNA may last only a few months), by simply being rearranged in new ways. Even new genes caused by mistakes can go on indefinitely.

Many genes won't survive for even one generation, however, if what Dawkins calls their "survival machines" don't work well. Survival machines here mean the plants or animals or bacteria that genes make.

There are no absolutely good successful kinds of genes because genes that work in one situation don't work in another (e.g., long legs are great for a gazelle yet bad for a mole.) The only thing the author says a gene must have to last is selfishness. Even as a gene works with another to build a long leg, it is doing so for its own survival. To the gene the only real rivals are the alleles which can take its place on the next generation. Other genes which have other functions and which help the gene's survival machine to produce another generation are not enemies.

The author then ponders why we die at all. An everlasting being continuing to reproduce would preserve a gene forever. He says that there are lethal genes that are no trouble until the survival machine is old enough to have passed on genes, at which time the genes kill the machine. Cancer is an example. An author called Medawar thinks that a lot of natural selection is about weeding out the machines that suffer from a lethal gene before they have offspring. This is an interesting idea to the writer who thinks we could increase lifespan by banning early reproduction or find some way to fool the gene into thinking the body is younger than it is. It is just an idea, however. The main point Dawkins makes is that the gene theory can make sense even though we do get old.

Secondly, why do we have sex? Wouldn't it be better for the gene if there was no cross over? Some creatures and plants do reproduce without sexual crossing over. But, if there is a gene for sexual reproduction—however it came to be—that gene itself is struggling to copy itself. Also, unused genetic material exists as extra protein in DNA genes. This is not harmful, so perhaps the gene doesn't need to discard it.

Dawkins really doesn't know the answer here. All that matters to his argument is that sex is a way to keep stirring, shuffling, and changing the "soup" that genes live in. Some genes become more common, some less common in living beings instead of in ancient seas. That is what evolution is about.

Chapter 4

Chapter 4 Summary and Analysis

Early small survival machines used up all the energy in the ancient soup, then some began to make their own food using sunlight. The offspring of these gene machines are called plants. Animals are the machines that make use of plants or other animals for energy. Over time, cells with identical genes in them remain connected to one another. Many celled life forms only appear to be individuals according to Dawkins, though he admits other scientists disagree with him. No matter how one looks at the issue, the animals become active and quicker than plants. The thing that makes this possible is the muscle connected to bones and tendons stimulated by nerves. Nerves work like a computer, thinks the author, directing certain things to happen. Here Dawkins remarks how much smaller neurons are than computer chips, but he is writing long before today's tiny nanotechnology.

Animal machines must stimulate the muscles to do things (bite, run) at exactly the right time, even though the first nerves could not have been connected to advanced brains. Yet even simple one-celled animals do indeed seem to act with purpose or intention. But actual machines can seem to act with intention and desire things too. The Watt Governor machine is one example of a mindless thing that appears to think. When the arms of this steam engine part spin too fast, force pushes some heavy balls up and close a valve which slows the engine down. It's like the Watt Governor wants to slow the steam engine, but it has no feelings at all.

Also, back in the 1970s when this book is written, computers can play chess on their own following pre-programmed rules. Dawkins' point is this: things can be made to happen automatically based on a set of rules arrived at ahead of time. The "controller" doesn't have to be actively doing anything to be responsible for future actions. Gene needs may have set in motion the future behavior of all animals and plants without directly doing anything. He reinforces his idea with a science fiction story about space aliens who send instructions through time about how to build a computer. When humans finally build it, it is a thing of danger.

Genes can only control how proteins are made in a plant or body. Genes actually are the instructions, so they're locked in to doing what's always been done. Some animals get hair, sharp teeth, or other characteristics. Genes can't predict things—which wouldn't help anyway because anything can happen once the animal or plant is born into a changing world. Because of the unknown risks, the kinds of genes most successful at creating animal brains are genes that make brains that can learn. Disasters happen to the animal gene machine that doesn't learn and those genes vanish.

If this sounds a bit magical, Dawkins shows that soulless, mindless computers can be programmed to learn and do complicated things if given a few rules. Is this consciousness like what people have? It's impossible to say. However, the author's point is only that genes can control behavior in a strong but very indirect way. As brains improve from mere nerves to thinking things, the gene's input is less and less direct.

An interesting experiment on bees proves this point. A disease called foul brood kills honeybees. Honeybees of one gene pool cut open the chamber of sick baby bees, pull them out and throw them out. One scientist discovers that there is one gene for uncapping a cell and a different gene for throwing out a baby bee. He manages to breed some bees with one gene only, with the result that that group opens cells but does not throw the babies out.

We don't know how the gene is "teaching" a behavior to a bee. Do they learn to like the taste of the cells that need uncapping? This experiment also shows that genes which normally "cooperate" to make an animal act some way could just as easily not work together. So, a gene likely to do something unselfish could be similar to another gene more likely to do something selfish. All the genes in the gene machine would need to sort of agree by means of the brain to do an action. And the main actions tend to be survival and reproduction.

Communication seems to be a gene behavior that helps one group of genes survive by influencing the behavior of another group of genes (another animal). Up until Dawkins' book, most scientists have thought communication is used for the mutual benefit of each party. But Dawkins says that sometimes animals "lie", or at least mislead other animals (even plants do this). He sets up the possibility that even when doing something "unselfish", the genes may be making a selfish choice and using communication to do it. This will be discussed in the next chapter.

Chapter 5

Chapter 5 Summary and Analysis

In this chapter the author talks about aggression between individuals which he calls "gene machines". He says that individuals within a particular species tend to have more direct interaction with one another than gene machines from different species because they must compete to survive using the same tools and fighting for the same resources, such as mates, living space, and food. So, if one believes Dawkins's selfish gene theory, it might make more sense for creatures within a species to kill and eat one another as often as possible.

But this is not the case. Cannibalism is relatively rare. Why?

The author says that there are hazards to out-and-out fighting, including wasting time and energy that could be put toward reproduction. For one thing, killing a rival could mean that a stronger rival takes the first one's place, making survival even tougher. So, does that mean that always selecting and trying to kill only the strongest rival is the best idea? Dawkins thinks not. It's dangerous. Sometimes it might be safer to wait around until a stronger rival dies or is killed, which is exactly what elephant seals do. The strongest male has all the females while the other males test him now and then, but otherwise they wait to inherit the females after he gets too old to rule or dies.

A kind of math called game theory helps to test and explain how real animals behave in the real world. Game theory gives points for success and subtracts points for failure at certain goals. Computers help crunch the numbers. One scientist has taken game theory ideas and come up with ESS, or Evolutionary Stable Strategy, to describe the real world behaviors that work best for each individual surviving in the wild. These ESS behaviors are a sort of big compromise that tends to happen over and over again because other behaviors get out of balance and fall apart. In nature, systems tend toward what is stable.

Dawkins goes on to give examples. Say there are creatures in a species that always fight or another type that always fakes a fight but always backs down—hawks and doves. Say winning a fight gives the creature 50 points, 0 for losing, -10 for wasting time and -100 for being seriously hurt or killed. Dawkins goes on to show mathematically that if the whole group is doves, with half winning each time, the "pay off" will always be a nice, stable 15 points. The minute a hawk comes in, though, he wins all the fights, he has many children, and they are all born hawks. Doves are temporarily wiped out. Now, things are unstable because any hawk can expect to win only half the time against other hawks but get seriously or slightly hurt half the time. Mathematically this is a -25 overall score. Weird as it may seem, if any doves appear, they begin to take over because they never stick around to get hurt and lose points.

This flip-flop is unstable. What is stable is when there are about half doves and half hawks. Actually 7:5 hawks to doves is the best ratio given the numbers Dawkins has used.

The author wants to prove that this strategy is best for each individual in a group, not for the group as a whole. More complicated math tricks follow to show that a group of total doves would work fine if life favored successful overall groups. If evolution were about groups, every creature would follow the dove model. But evolution is about selfish gene machines and so the hawk has such big advantages against doves that hawks often appear and survive. In the real world, competing individuals have to do the best they can in a mixed bag of 7:5 hawks to doves.

One way populations of animals actually do behave is that they "lie". They do not communicate clearly if they are hawks or doves. Dawkins asks readers to imagine what happens when other types of animals come into existence. One could have a "retaliator", which acts like a hawk when approached by one, and a dove when he meets a dove or another retaliator. A "bully" would act like a hawk but then would always back down like a dove. A prober-retaliator would attack and even push a fight, but if he meets a dove he acts like a dove. When attacked he retaliates.

When game theory experts actually run a collection of these possible types as a computer simulation; the retaliator model is the most stable with the prober retaliator second. Hawks lose to doves as we've seen. Pure bullies are wiped out by hawks. Doves do well mixed in with retaliators and tend to start to overpopulate, but then prober-retaliators overwhelm them. A mix of retaliators, doves, and prober-retaliators tend to arise, which is exactly what happens in nature. Creatures within a group tend not to fight to the death all the time, but engage in various controlled conflicts.

The ESS scientist also has another way to look at aggression in a species. This is called "war of attrition" and it is calculated based on how much time and energy a particular goal is worth. How much time should an animal take out of a busy day of hunting to compete to win a female? Calculations prove that the best bet is to make the individual's behavior unpredictable to others. In nature, all kinds of threatening communication help animals fake their intentions to continue a particular struggle.

Now the author considers what happens to animal behavior when things are unequal or asymmetrical. For example, in real life, some competitors are weaker in different respects than other competitors. Sometimes winning a particular goal is worth less to one individual than another. What if luck isn't on the individual's side, for example, if it shows up too late to seriously be in the running? Then certain basic rules for behavior tend to evolve; for example, "intruder retreats". After all, the intruder doesn't know the area, may be out of breath, or may be outnumbered. It makes sense to back off in such a situation, and this sort of behavior often occurs in nature.

One scientist named Niko Tinbergen does an interesting experiment to show how intruder retreats works. He puts nesting fish that usually protect their nests in glass tubes. Then he moves the fish nest and all closer or farther from another nesting fish. The one that thinks it is an intruder always backs off!

Dawkins goes on to ponder paradoxical strategies that wouldn't evolve and wouldn't work. A few of these strategies do seem to exist in nature, but these are only things we don't quite understand, thinks the author.

Memory of having lost fights is common in animals as unsophisticated as crickets. Those that lose tend to give up sooner and accept a lower position in a group. This strategy actually leads to fewer serious fights. Even in groups like a flock of chickens, in which each hen knows her place, the stable structure leads to higher egg production.

Looking back at these conclusions, it's easy to see that cannibalism would be like pure hawk behavior and not very stable. Non-cannibals naturally arise.

It's a little different ball game when it comes to animals from different species because they are made differently and want different things. Animals from different species take advantage of group strategies for their own individual survival. For instance, a mutant antelope that fights a lion has a small chance of survival. One antelope running in herds of a hundred others has a one in one hundred chance.

Dawkins predicts that ESS thinking will explain a lot of environmental behaviors. He says it also can apply to how genes work together in a body. Those genes that cooperate best (like a group of equally left handed and right handed oarsmen on a fast boat) happen to win. Winning combinations keep cropping up because unbalanced combinations, like too many hawks, too many doves, don't survive. The competition is not happening just on the level of the whole animal, but on the level of the genes. In the next chapter Dawkins promises to consider what happens when gene loyalties are divided between different bodies; say, in a parent's body and a child's body.

Chapter 6

Chapter 6 Summary and Analysis

Dawkins attempts to zero in on his main idea a bit more precisely in this chapter. He explains that what he means by a selfish gene is actually a bit of DNA and all its replicas (copies) distributed in any living thing "trying" to program these bodies to act in ways that will help make more of itself.

Sometimes for a trait to exist in nature, gene fragments from two different sources have to come together in one body. This is called a recessive gene, and it can exist or ride along through many generations without doing anything noticeable. More on this subject will be presented later.

Also, genes or gene fragments sometimes have more than one effect on growing a body. Altruistic genes—or genes that somehow program bodies to do good things for others even if these altruistic genes have other functions as well—are pretty common in nature, especially when it comes to family. A mother animal often saves a child animal, for example. This makes sense with the selfish gene theory because both the mother and offspring probably carry bits of various genes cooperating to survive in a survival machine. So why do genes that have the effect of protecting or caring for others continue to exist?

A scientist called W.D. Hamilton proves that brothers, sisters, and other close relatives will tend to get the gene for altruism because this is a successful way of saving copies of a gene, even if the body with the particular copy of the gene that saves others dies.

The author uses Hamilton's mathematical calculations to show that two parents have a fifty-fifty chance of giving their particular genes to a child. Each parent is related to a child by one half. (And to themselves by one). However, cousins and siblings and grandparents are related to children and to each other in varying amounts. Hamilton provides a formula for calculating the possible relatedness. Go back to a common relative (same mother, father, uncle, and so on) and multiply one half by itself once for how many steps back in the generation one has to go to reach the ancestor. If they have another common relation (like the same parents, for example), do the same math and add this to the total.

Cousins have the same two grandparent: one half times itself four times for grandma. Plus one half times itself four times for grandpa. If one does the math, one comes up with one eighth. Your cousin has about one eighth likelihood of carrying a particular gene you carry.

Once understood on a mathematical level, family altruism makes sense. A gene that commits suicide to save five cousins would exist in smaller numbers and might die out (1/8+1/8+1/8+1/8+1/8), but a gene that saves five brothers (1/4+1/4+1/4+1/4+1/4) would have a better chance to continue. Saving enough copies of itself makes up for the loss of one. Dawkins points out this is definitely not about survival of a total species, just of a collection of genes.

Other factors figure into the way animals behave toward others possibly sharing their genes, and the author assigns mathematical values to them: benefit to the animal itself minus risk to itself plus or minus the relatedness percentage to the animal. The final number is called a net benefit score. Dawkins uses these numbers to show that an animal could logically make a call to show other cousins and siblings and children that food is available, even if some unrelated members might gobble food. This is especially true if the first animal will get enough to eat first (endures less risk), plus close relatives will be fed.

Other apparently noble actions might boil down to "smart" strategies that survive because they help groups of genes multiply. For example, an older animal that has pretty much passed on all its gene copies might be more successful caring for a younger animals that will create more copies when grown. That's why often we see parents saving children, not visa versa, even though the older animal is one hundred percent related to itself and only one half related to its child.

Of course animals can't do math, and have no way of knowing if their siblings are actually related to them. What if the father isn't the father? If a gene machine behaves helpful toward others that resemble it, the statistical effect may turn out positively anyway, says Dawkins, because there is a high probability they are related (humans are the exception in the case of racism because of mistaken ideas about how we are related). The author mentions how whales and baboons work hard to rescue or save others. He also shows that animals can be tricked into raising a child that is not her own and wonders how this may happen. Perhaps the mistaken mother gains practice for her future offspring, suggests Dawkins.

The author shows that birds have evolved various abilities to help only their own offspring. Gulls can't and don't need to recognize their eggs because they lay eggs a few yards away from others. They do recognize their chicks because other gulls will eat them. Guillemots lay eggs on a flat place where they could roll into other nests, and they do recognize their eggs. Cuckoos take advantage of other birds being nice to anything in their cozy nests by substituting their eggs for the real ones. Cuckoos have evolved eggs to look more and more like the hosts they replace because the ones that are not detected and thrown out of the nest survive.

In general, the female tends to be more sure of her relatedness to children than the father does, and sure enough, mother child altruism is more common. Brothers and sisters can't be sure they are really related, so brother sister altruism is less common than parental care and sacrifice. Writing in the 1970s, Dawkins says a scientist named Wilson thinks altruism laws apply to every relative connection but parent child relationships, but that makes no sense to Dawkins. Parents and children are very closely related.

Chapter 7

Chapter 7 Summary and Analysis

Dawkins believes people mistakenly want to think of parental care as something different than other evolutionary behaviors. He points out that there is a big difference between making new gene machines and taking care of existing one. Caring for young has a very different meaning for different animals. The author says from a gene's point of view you are just as related to a baby brother as your own baby son, but human mammals tend to favor the son, so really, if his theory is correct, brothers ought to protect one another as powerfully as they do their own offspring.

The confusion comes in part, he says, because a person named Wynne-Edwards teaches that groups of animals evolved for the good of the group as a whole. He believes they could intentionally reduce their own birth rates for the good of the species. It's an appealing idea because humans should probably limit their massive population growth, says Dawkins. Famine, war, or birth control may cut down on the rate even though medicine and better food save more lives per generation. People try to balance population, but the author says genes do not think about doing any of this because they cannot think. Why then do animal populations not explode like human populations? Old age almost never kills wild animals. And most creatures only have a specific, limited number of offspring in their lives. Why have more?

Before he begins his argument, Dawkins wants readers to remember many gene machines fight over territory. Wynne-Edwards thinks territories are just symbolic, but the author disagrees and will come back to his argument a bit later.

This book's author says that another scientist who has studied egg clutch sizes shows that there are negatives as well as positives to having a lot of eggs. Feeding baby birds takes a huge amount of work. If not enough food can be found, the baby birds will all die. But the birds are not laying a smaller number of eggs for the good of all birds of their species. They are doing it for their own selfish gene offspring. Genes for too many children die out (people are an exception because we have constructed elaborate safety nets for our own benefit that happen to benefit others, such as welfare to feed the hungry. The author's own opinion on a political issue shines through here. He says that birth control is criticized as unnatural, but so is feeding the poor).

Back to territory behavior goes Dawkins. When an animal fails to get a territory and so isn't able to win a mate, it gives up and does not attempt to breed at that time. Wynne-Edwards sees this as an argument that animals behave for the good of the species. Dawkins says that by waiting for a territory winner to die and taking its place, a gene machine might have better odds of breeding after all, rather than being killed in a fight on another animal's home turf. So there can be a selfish-gene explanation for the behavior.

In mice studies where female mice become less fertile as the population grows out of control. Wynne-Edwards believes group selection makes this happen. Dawkins thinks that mice, which become less fertile and stressed in overpopulated conditions where famine could soon occur, tend to be more successful raising their small number of children. These children survive to pass on the gene for making fewer children during overpopulated conditions.

Another idea made popular by Wynne-Edwards is that a bunch of animals hang out together making a lot of noise at various times of years in order to show one another how overpopulated they are. He suggests that when there is a lot of overpopulation, they have fewer young. Dawkins says this hasn't been proven, but it is entirely possible that clues in nature might trigger the birds into laying fewer eggs. And if so, they might make a great deal of noise on the nest to appear to have more children and to be a strong family which others should not "mess with".

Chapter 8

Chapter 8 Summary and Analysis

The author now investigates if a parent should show favoritism to one offspring; for instance, protect or feed one child more than others. R.L. Trivers invents a way to think about parental care called "Parental Investment", or PI. Higher PI means giving more to one at the expense of another child. Dawkins wants to expand the idea to all adult care givers, including related adults. He calls this AI or Altruistic Investment. There's only so much AI energy, time, and effort any creature can offer.

Genetically, there is no reason to favor one child. Each is related to the parent by one half. But if there is something wrong with one of the offspring, it will take more energy to raise and will "cheat" the others. Some pigs do eat the runt of the litter and use him to make milk for the others. Other factors figure in. A mother may have put a lot of energy into an older child so should act to save that one, but sometimes an older one can live with less because it is stronger. This is why mammals wean young.

Human menopause is a bit of puzzle. Other animals and human males don't do this. Studies by Medawar prove that women are not as good at raising children when they are old. In fact, a child of an old mother has less chance of survival than that mother's grandchildren. So from a gene's point of view, the old mother is better off helping to raise grandkids.

Now Dawkins explores whether a child can trick the parent into a great AI. Children are just as related to each other as to their parents—by one half. So, although a child may struggle to get food from a parent because, after all, he is one hundred percent related to himself, an older child that will suffer less from the loss of food might give up food for a younger, more helpless member of his own gene pool.

Weaning serves an older child because it can survive as well on solid food, whereas another member of his gene pool—the baby—cannot. Baby birds scream to show feeding parents how hungry they are. Often they cheat, but the nest doesn't just get louder and louder because the screaming uses up energy and attracts predators. Carelessly loud gene machines don't survive. The runt of a litter often gives up and dies, limiting the waste of resources on him. Dawkins thinks runts are a way animals hedge their bets. If the extra one survives, great! But the parent tends to feed the most robust ones first.

Another researcher points out that normally a baby bird in a nest will not "blackmail" parents into giving it more food than its brothers by screaming so loud that it attracts predators. This is a danger to itself and other gene related babies. However, the author notes, cuckoos are born in the nests of other birds. Do they do this a kind of blackmail to get more food than unrelated brothers and sisters? This isn't known. Honeyguide bird eggs are also laid in the nests of other birds, and they immediately kill their nest mates.

Astonishing research by three Spanish scientists saw baby swallow lift an egg of a magpie out of its nest and throw it on the ground using its back as a lever. The parent birds don't seem to do this. Dawkins wonders if the baby does this because it could tell the egg was not related to it, or perhaps the swallow normally kills its brothers.

Dawkins describes a theory which goes like this: any gene that lets a child succeed and its parent suffer can't survive because the child would suffer when it became a parent. The author doesn't quite agree with the theory because he points out that other relatives are involved, and that there are costs to litter mates and so on. In general, Dawkins believes a sort of compromise evolves where the generations each get a reasonable amount of what they want. He goes on to apologize for making life sound so cruel and harsh, but he also points out that humans are not guided only by nature. We can teach our children not to lie and cheat and ask for more than they need, just as we can learn to treat them all equally.

Chapter 9

Chapter 9 Summary and Analysis

Moving forward with the selfish gene theory, the author suggests that mates (male and female) share no DNA, but they do share a half interest in each of their offspring. It might be useful for a gene machine to somehow cheat the other gene machine parent into investing more energy into protecting and raising offspring while the cheater goes out and makes more copies of itself with someone else. According to a scientist named Trivers, a great deal of mistrust and exploitation goes on between male and female mates. He looks at breeding as a real war of the sexes. To examine this idea, Dawkins tries to define what the basic male and female animal (or plant) really are. Sperm or pollen cells of males are called gametes, and they are smaller than eggs or gametes of females (some fungi use a kind of sex-like joining of equal sized cells, but there is no true male and female cells and each gives an equal number of genes to the next generation).

In actual sexual reproduction—plant or animal—one cell from each parent gives one half the DNA for the offspring. Typically, the egg has more food reserves for the growing gene machine, and the female cell is at a disadvantage. It's easy to see how this sort of situation might have occurred in the early days when only molecules were floating around. Smaller cells would naturally have linked on to larger ones and been more stable together. Very small cells would have a better chance of surviving if they could move around well and if there were a lot of them. Dawkins calls the female large cell the honest strategy, and the sneaky small cells the sneaky strategy. Both kinds of cells would have a good chance of success.

Since a single male gene machine is able to make lots of male cells, it would seem that not so many males would need to be born—if creatures evolved for the good of the species. But, if things evolve based on the success of the gene, a balance of more females could not last for too long. The advantages of being male would mean that any sneaky male would be wildly successful. Soon there would be more males, then the "pendulum" would swing back to more females. Finally the ratio would settle around 50-50. The chances of being born male or female even in animals where only a few get to breed really are around 50-50.

Remembering that animals and plants are being considered gene machines for the purposes of this book, a particular gene will find itself in a male or female body about half the time. Females start out putting more into their children in terms of food inside the egg, so it makes more sense for the female to be the most caring of the investment they've already made. It's true that in nature the male is more often the one that abandons the female to raise young without him. On the other hand, some evolutionary influences have resulted in males that help raise young.

What if a female tries to trick a male into helping raise a child that's not its own? Dawkins explains that there are various methods in nature for the false father to fight back. Male mice let out a chemical that can make a female drop all unborn fetuses from another male. Male lions kill the cubs of the previous males. And other animals have long courtships during which the male holds off any other males who might get to his female.

From the female's point of view, refusing sex until the male has invested energy into the welfare of the offspring is a good way to avoid being "used". Female animals may wait for the male to build a nest, for example, forcing him to put off breeding with someone else, before she allows him access to her egg. Trivers thinks that then the male animal has invested so much energy, it would be a waste of time to leave. But Dawkins points out that the male would do even better still to leave after building the nest. The author goes back to game theory to explain why animals don't usually abandon the females after winning her in a courtship battle.

He assigns points for coy females who wait to have sex and fast females who breed right away, faithful males who do long courtships for sex and philanderers who go looking for other females if the female won't breed right away. A creature loses three points for wasting time, loses twenty point for energy spent in raising a child, but gains fifteen points for every successful child raised. If a coy and faithful animal raise the child together, they each only pay ten points on child care, waste a small amount on energy expended, but earn for successful child rearing with the result of plus two points. He shows that over time the small gain of cooperation is more stable than totally taking advantage of the opposite sex. In one case, the philanderer gets shut out by a rise in coy females because the fast females pay the total cost of raising a child on their own, minus twenty, which is a lot more than zero that coy females waste. Once coy females predominate, only faithful males are successful. Trends just naturally flow back to coy and faithful.

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Dawkins taks about some of the things female animals do to get males to care for them. Some female birds act baby-like and demand that the male feed them. Female humans may wear pouty childlike expressions, claims Dawkins. The praying mantis actually becomes food for his future eggs by being eaten by the female.

Natural selection would favor males that might pretend to be faithful or females that could spot a fake. In many animals, the female does end up doing more work, except in the case of underwater species. Dawkins says where fish are concerned, eggs are heavy and will not wash away so a female fish may lay them when she likes and abandon them to whomever wants to fertilize them. A male fish has light sperm that could float away, so many species of fish fertilize after the eggs are laid and are left "holding the bag" when the female swims off. Someone's got to guard the eggs.

In other land dwelling animals, females do all the raising, but insist on only breeding with the strongest, best quality male with the best chance of survival. Often males evolve exciting visual proof of their superiority, like long tails or big muscles. A scientist called Zahavi claims that uselessly long tails on male birds of paradise are there to prove that even with a dangerous dragging tail behind them, they are super strong enough to survive. The author pooh-poohs the theory by Zahavi but can't really come up with a good explanation of why the tail exists.

Dawkins wraps up the chapter with a discussion of traits that are usually male or female. Males tend to be brightly colored so they are picked more often for breeding, even if a higher number of them are eaten by predators. Females tend to be more selective about who they mate with. After all, her initial cost is greater and if they become pregnant with a child that will be infertile (as a horse will be when breeding with a donkey), or bad genes (which happens in the case of incest), she will waste even more energy growing the fetus that can't pass on good genes.

Dawkins suspects humans tend to be more on the coy/faithful type of model with a tendency for males to be more promiscuous. But unlike animals, the human female works extra hard to be attractive. It is as if the female is the one trying to be selected, and this puzzles the author.

Chapter 10

Chapter 10 Summary and Analysis

The author explains that he has discussed parents, sexuality, and fighting behavior between animals of one species, and now he plans to consider animals that live in unrelated mixed groups, like zebras and gnus. He promises to tie up loose ends brought up in chapter one, to explain away other behavior that's not really altruistic but appears to be, and to look at social insect behavior.

First, most group behavior helps the individual. Hyenas hunt bigger prey as a pack, penguins keep warm, and fish and birds move more smoothly together. W.D. Hamilton explains the idea of how groups form. Hamilton says that if each animal has a bigger chance of being eaten by a stalking predator if it is isolated, it will naturally crowd closer into the center of a group. This is how herds are formed.

Bird calls that warn other birds of danger may seem unselfish. Although the bird which calls attracts the attention to itself, the calls birds make consist of sounds that are hard to pinpoint. Obviously, birds whose calls make them easy to spot die out of the population. A few reasons the birds might call in the first place are listed. For example, if one bird wants to hide by freezing and trying to camouflage itself with the background, the rest of the flock must also hold still to make the plan work. Birds that fly up into trees need to wait until the exact moment when others fly in order to confuse the predator and to escape. Birds that call together would have that advantage.

An interesting gazelle behavior is called stotting. This is when Thompson gazelles jump high out of the herd directly in front of a predator. A. Zahavi offers what the author calls a "daring" theory. Zahavi thinks predators normally attack weak, old, and helpless animals because they are easiest to catch. A gazelle that leaps so high is indicating how young it is and therefore how difficult to catch it might be.

As promised in the introduction, the author turns to insects now. When a bee stings, it dies. Certain ants hang from ceilings and turn into living food packs. Termites share food so completely it is as if they have one single stomach. One scientist thinks that these sorts of behaviors make perfect sense when the insects involved are sterile, or unable to mate and pass on genes. They do, however, share a huge amount of gene material with the other breeding insects in the hive, so it is to their benefit to help the breeders survive in any way they can.

Insect colonies are usually a huge number of offspring descended from the same mother, often a queen that does nothing but lay eggs. In an earlier chapter, Dawkins has said there is a big difference between bearing young and caring for them. Now he suggests that for genes to survive in some animals, the parental animals share the responsibility of bearing and caring equally, and in insects different individuals either do one or the other. A team of scientists, Trivers and Hare, explains why the workers or caregivers who don't get to breed continue to exist if there is no advantage to them.

Male insects like bees come from unfertilized eggs. The queen uses stored up sperm from her one mating flight to fertilize some eggs—the female workers—but not the others which become males. Males have one half of a set of chromosomes, and the females have a full set. Only the females given special food can grow into queens. A male gets all his genes from his mother, the queen, but she only gives half her genes to her son because he only has half a set of genes. The sisters all have the same father with only one set of identical genes and the same mother. In that way, they are like identical twin mammals who come from one egg fertilized by one sperm.

So, a female worker's chance of sharing a gene with her sister is actually greater than the chances that if she were to have children she could give that gene to her child. At least half of her genes are from her dad and identical to her sisters'. Plus, there is also a fifty-fifty chance that a particular gene came from her mother. She's three quarters related to her sister. If she had offspring, she would only be only one half related to them (half her genes, half her mate's). Using the queen to make sisters would be a useful way to pass on genes, and sterile sisters would develop because children would be less likely to pass on genes. Some more complicated math also shows that the best ratio of females to males in this case is three to one.

Otherwise, the queen of an insect colony would attempt to make half female half male offspring. This is the ratio that works most successfully for a parent, as the book shows in an earlier chapter. Trivers and Hare find out what happens to the ratio of males to females when a queen of a hive has more influence over the gender of her offspring. Certain ants steal eggs from other ants and make these into hive slaves. The slaves are tricked into working for ants which aren't related to them. The enslaving ants do better for their genes to help the queen who they are related to instead of the other workers they are not related to. In these species, the workers are sterile and all the reproducers made by the queen come out one to one, half male half female.

Dawkins has a little more trouble explaining honeybees, who seem to make a great number of extra males, but he says the investment in extra workers has to be made because new queens fly off, talking part of the hive with them. Also, since the bees are most closely related to their own queen from their own generation, they don't try to stop her from breeding with whomever she can, even if that makes her eventual offspring less related to them.

The words Dawkins has been using throughout this chapter are related to farming. Actually, he tells us, the honeybee's care of the queen for her eggs is not truly farming her; however, insects do farm. Some ants grow a plant that feeds a fungus that they eat. Others take special care of aphids, protecting them, carrying them around, and milking them for food. These are examples of something called symbiosis in which both parties get something positive out of caring for each other.

Lichens must live with green alga to survive. Cells have little chemical factories in them called mitochondria, and some scientist think these energy engines are simply cells that joined forces with other cells to survive long, long ago. A virus is a batch of DNA surrounded by a protective coat of protein, and some scientist think they are simply cells that broke off from colonies of cells, like renegades looking for a hideout.

Using more game theory math, Dawkins tries to explain how an altruistic symbiotic would arise in the real world. He imagines a bird colony where pulling the tick off a spot the bird couldn't reach on its own head could save the life of the bird. If all birds do this, they reach a stable existence until along comes one cheating bird who wants a tick removed but doesn't return the favor. For a time, the cheating birds outnumber the sucker birds. Now if grudger birds (which remember and refuse to help cheats but do help themselves or suckers) come into the population, their growth starts out slowly, but once they've learned which cheats to avoid, they become the only ones left. He actually watches the game run on a computer and sounds very amused by the process.

Referring to observations by the scientist called Trivers, Dawkins explains how stripped cleaner fish are given access to bigger, fiercer fish even though some cheating look-alikes sometimes take a bite out of the fish they're supposed to be grooming. To get around the problem of being bitten, or of accidentally biting a true cleaner fish by mistaking it for a cheat, fish actually set up cleaner stations where only the cleaner fish can be found. The bigger fish wait in line, like patrons at the barbershop.

Dawkins urges readers to consider how our personality traits may have developed to help us cheat, avoid cheating, or avoid being cheated upon.

Chapter 11

Chapter 11 Summary and Analysis

This final chapter is the most daring and original of all. First, he examines the question, "Is man unique?" Yes is the answer he comes up with, because humans have a true culture passed on by language. Other animals, like the saddleback bird of New Zealand, do pass along evolving songs. They listen to one another and sometimes change their song based on what they have heard, so this is not a genetic passing on. But human cultural information is far more complex and the way it is passed on is unique. Still, the author and other thinkers believe that the way culture is passed on is similar to the way evolution works. And why shouldn't it be?

Genes are replicators, but it's conceivable that on another planet replicators may have arisen in chemicals other than those on earth. DNA, life would be different, but it might replicate and reproduce in a similar way. Human ideas, which the author nicknames memes, could also replicate the same way.

If a memes is appealing it will spread. If it is appealing it will be copied by many generations, and it will become a stable force across generations. Some scientists have gone so far to say these memes will become an actual part of the structure of brains.

The idea of God is one such appealing idea found in vast numbers of cultures, says Dawkins. Naysayers tell Dawkins there must be a survival advantage to believing in God, but the author disagrees. He says as long as an idea remains appealing it will duplicate until something more successful challenges or replaces it. To Dawkins, the "meme pool" is like a "gene pool" of the gene argument. The meme pool is the soup in which memes float . . . all the brains that remember an idea, the printed words, and music written about an idea.

The author admits he's not too sure about the next part of his meme to gene comparison. Do memes last if they can make exact copies of themselves? Dawkins thinks memes are changed a great deal by each individual that accepts and uses them. On the other hand, skin color changes slightly throughout generations, despite the fact that the same genes are passing this trait on. Perhaps the way we define the meme is similar to the way we define a gene—with no easily marked beginning and end. For example, all kinds of people believe in Darwin's theory of evolution, but as this book shows, they interpret it in slightly different ways.

The author can't take his theory as far as making a connection between memes and chromosomes or alleles. He thinks that memes are more like primitive molecules floating in ancient seas. But, memes do have to compete for the limited space in human brains, cultural methods of recording, and so on.

And sometimes powerful memes overrule genes, as for example, when a religion enforces celibacy to keep priests focused on their own meme and not on the genetic predisposition to breed.

On the positive side, memes can outlast individual genes, so that even when one's descendants are long gone, a person's ideas, artistic, or scientific creations can last. Dawkins finds this wonderfully rewarding. Humans have foresight, so we can shape our short sighted, self centered memes to do things that might help everyone's genes in the long run. Maybe humans are capable of actually behaving in a truly altruistic way, so we can become the only unselfish gene machines that have ever existed.

Unknown to the author at the time of the writing of the book, the theory of memes becomes an entire science in itself.

Characters

Richard Dawkins

According to the biography in the book jacket, Richard Dawkins is born around World War II (1941). He attends sophisticated schools such as the Oundle School and the Balliol College, Oxford in order to earn his PhD in zoology. He then becomes an assistant professor for Niko Tinbergen and finally the Assistant Professor of Zoology at UC Berkeley in the '70s. What the book published in 1976 cannot predict is that "The Selfish Gene" changes drastically the way that many think about evolution.

Further, Dawkins continues to write books that refine the specifics of the selfish gene theory as well as to talk about how gene inspired traits can then go on to affect the gene machine's environment (or be affected by the environment). For all this work he wins a special chair (or honorary position) at Oxford. After much thought and "soul searching", Dawkins comes to believe that God is not necessary for evolution to take place. His belief that we alone can and should drive our own destiny grows and he writes and lectures on these topics. At the time of this critical review he enjoys bestseller status for a book entitled "The God Myth".

Regardless of his religious position, Dawkins is respected by evolutionary scientists for his precise and logical explanation of Darwin's theories. He is often called Darwin's rottweiler.

Charles Darwin

Darwin is an eighteenth century naturalist who joins a long sea expedition in order to observe life in places other than his English homeland. Contrary to misunderstanding, Darwin is a Christian who studies theology and has no quarrel with church teachings. He simply loves nature and wishes to take notes on life forms. However, as he travels to South America and to the Galapagos Islands, he begins to see evidence that animal and plant life has existed for many more years than the six thousand or so mentioned in the Bible. When he comes back from his voyage he publishes a book of notes and he lectures on the various creatures and fossils he has observed.

It seems to Darwin that all things have evolved from a few basic species through the process of struggle and survival he calls natural selection, but he hesitates to put this most controversial idea onto paper for quite a few years after his return from his voyage. Eventually, a doctor who has also come to this conclusion based on Darwin's notes, writes to Darwin and says he has similar theory and wants to publish. In order not to get "scooped", Darwin publishes his theory of natural selection. Religious thinkers attack him as viciously as others embrace him.

After his death, many people use and interpret Darwin's ideas to suit their own beliefs. Scientists have used it to help them find the origin of human life, and Nazis have twisted it to justify destruction of people they considered inferior. Today, the majority of scientists accept Darwin's theories because it has led to so many advances in medicine, biology, and earth sciences. Dawkins seems to find deeper and deeper truths in Darwin's ideas, and credits Darwin as the first person to clearly explain why we are here.

Verno Copner Edwards

V.C. Edwards might represent the old guard of evolutionary thinkers. His ideas, most famously set out in "Animal dispersion in relation to social behavior", published in 1962, tries to prove that animals behave in ways that work for the good of the entire species. He even believes that animals may control themselves in mating or breeding so that the greatest number of them may thrive and survive. This notion is popular, thinks Dawkins, because humans want to believe kindness and goodness and altruism are natural in the world.

Preposterous, says Dawkins. There is simply no way such behaviors can have evolved. Dawkins sweeps away the idea that an animal fails to breed for a noble reason using game strategy logic. Perhaps the creature faces less risk simply by waiting around to breed at the next opportunity.

Ronald A. Fisher

Ronald Fisher is born in 1890 and grows up to become a statistician, geneticists, and evolutionary biologist. The scientist has to compensate for very bad eyesight by imagining complicated problems in his head. His brilliantly developed math mind helps him arrive at many "firsts", but the one most interesting to Dawkins is his way of calculating in exactly what proportion genes get passed into a population. Fisher's formula can show mathematically how related an individual is likely to be to its parent, child, or brother. He also studies why populations have a 50-50 sex ratio. Dawkins admires these mathematical explanations of Darwinian theory.

Unfortunately, Fisher becomes convinced that it is correct to shape human populations so that the most intelligent and noble survive. This is called eugenics, and is responsible for much cruelty during World War II.

William Donald Hamilton

During his lifetime, W.D. Hamilton does much to explain why related individuals protect one another. Dawkins accepts this thinking and uses much of the math worked out by Hamilton to make his point.

Although Hamilton publishes his findings in 1964, Hamilton's name is not even mentioned in either major ethology text book published in 1970, and Dawkins thinks this is because the math is quite complicated, so the publishers don't understand the importance of the work. Studying in Brittan at Oxford University, he leaves behind a body of work which leads to the creation of the science of sociobiology. Hamilton's belief that genes drive family behaviors is right in line with Dawkins's theories.

Konrad Lorenz

Author of "On Aggression" and a Nobel Prize winner, many people think of Lorenz as the founder of the study of animal behavior, or ethology. Lorenz eventually wins a Nobel prize for his work studying various birds from a medical and psychological point of view. However, Dawkins takes exception when Lorenz talks about how only the best individuals are "allowed" to breed in order to preserve the species. Dawkins points out this is not what Darwinian theory actually says. The way Dawkins looks at it, species exist because a number of selfish individuals within a species succeed in passing on their genes, but animals do not work together to help the species survive.

John Maynard Smith

Smith is the author of "The theory of games and the evolution of animal conflict", published in the Journal of Theoretical Biology (strangely, he begins his career in World War II as an aeronautical engineer, but jokes that his poor eyesight was an evolutionary advantage because it keeps him from going to war and getting shot). Smith goes back to school in zoology and starts researching population genetics, during which time he hears about game theory and begins using it to craft his ideas.

In the paper and in his research, Smith makes up a kind of logic problem where he turns real behavior into rules for a game. The object of each game becomes reaching an ESS, or evolutionary stable strategy. In real life, after all, groups of plants and animals survive in a relatively stable state for various periods of time.

Dawkins thinks this is the single most important approach to solving biological problems in the century. In fact, today this kind of computer modeling is often used to predict the behavior of complicated systems.

Robert L. Trivers

Dawkins frequently quotes this scientist, which is rather unusual because, according to the book jacket, he is only an Associate Professor of Biology at Harvard. This is not a very advanced position. In addition, Trivers writes the foreword to this book, and endorsing the work of someone who helps write the foreword to ones own book seems a bit odd.

Research outside the Selfish Gene shows that Trivers is a Harvard graduate who goes into psychology when he has a nervous breakdown but who leaves the study because he thinks psychology theory isn't very good. He earns a graduate degree without even getting a BA, but goes on to become a leading evolutionary biologist who helps explain adaptive behaviors of self deception as well as what happens when certain genes within an organism have different needs than others in the same organism. He writes children's book that are never published because he represents Darwin's theories as fact. This interesting, controversial figure inspires Dawkins with his careful study and predictions about how parents should invest in raising their offspring.

George C. Williams

Williams seems to have inspired much of Dawkins's major theory. He too looks at evolution as a contest between genes, and he sees individuals as a collection of genes. A scientist who studies fish and uses their behavior as examples in his work, Williams argues that things don't exactly adapt. It's more precise to say that nature selects among genes or individuals that fail. In other words, failures die.

Williams is a professor at UCLA, an author and a Crafoord Prize winner.

Dawkins uses the definition made up by George Williams for the gene as "that which segregates and recombines with appreciable frequency".

Amotz Zahavi

This evolutionary biologist living in Israel raises theories that Dawkins finds interesting. He is the author of "Reliability in communication systems and the evolution of altruism" published in the magazine, Evolutionary Ecology. Dawkins has doubts about some of Zahavi's theories; in particular, the idea that baby birds might blackmail parents into giving more food by shouting so loud as to attract predators. Dawkins thinks that would lead to a die-off of the babies carrying that sort of gene. Another of Zahavi's ideas intrigues Dawkins. Stotting is when grazing animals jump up in front of lions, apparently to protect the herd. But Zahavi thinks this is a selfish display by those animals to show they are too fit and spry to catch.

Objects/Places

Alleleappears in non-fiction

Sexually reproducing beings inherit a bit of DNA called a chromosome from their mother and another bit from their father for each trait that they may eventually have. So, one might get a blue eye bit from one parent and a brown eye bit from another parent. When two bits of instructions for the same trait exist, they are called alleles of one another.

In humans, there are forty-six chromosomes made up of twenty-six from one parent and twenty-six from another. The chromosomes pass on information about how to build the body because they are made up of molecular strings of coded instructions called genes. The selection of which gene instruction or allele will actually dominate has something to do with random chance and with the ability of one to override the other. For example, the brown eyed allele will always be dominant. The other allele does not vanish from the planet, however. It will be passed on to the offspring when the being breeds. If it finds itself paired with another blue eyed allele from the father, blue eyes may then appear.

Chromosomeappears in non-fiction

The chromosome is a big DNA molecule made up of many genes which themselves are made up of strings of nucleotides. Some like to look at the chromosome as the pack of DNA materials and things that regulate the DNA. Different animals and even different cells within a creature have differently shaped chromosomes. Perhaps because it is only thought of as a sort of package, Dawkins speaks little of the chromosome and uses the term loosely.

Computer Game Theoryappears in non-fiction

Many of Dawkins's arguments seem inspired by computer game theory, which must have been relatively new and unsophisticated in 1976 when the book is written. Taking advantage of the computer's ability to run millions of calculations relatively quickly, zoologists and statisticians create games where they can observe the logical outcome of certain behaviors without waiting for millennia of evolution to occur.

In this book, Dawkins uses computer game theory to study what happens to a group when all the females mate frequently or hesitate. He also experiments with different kinds of aggressive behaviors to see which posture results in a stable state.

DNAappears in non-fiction

DNA is the basic chain of molecular structure that is the building block of all living things, plant or animal. Dawkins says from bacteria to elephants to oak trees, we are all made of DNA, which is itself made from simple proteins like that found in the ancient seas. Too small to see firsthand, scientists have determined that DNA is made of twisted molecule strands, or chains. These molecules in the chains are called nucleotides and there are only four varieties. Scientists label them A,T,C, and G types. The way these molecules are arranged will determine what kind of plant, animal, or even microbe it creates.

It is essential to Dawkins's theory that the reader understand and accept that only tiny, relatively arbitrary differences exist between living things, because he wants to prove the same rules and processes apply to all evolution and have led to the diversity of life.

ESSappears in non-fiction

The full term is evolutionary stable strategy. In nature, animal behavior, such as flock or herd behavior, remains pretty much the same over extended periods of time. Birds don't suddenly abandon mating behaviors, lions do not become vegetarians. So, in nature it is clear that relatively stable systems evolve over time. Scientists who wish to study how a system of animal behavior come to be make reaching a stable state the object of different computer modeling games. Starting with such and such a rule, how long will it take for the group to reach a stable state, and what sort of stable state is reached?

In this book, Dawkins marvels at how frequently certain behaviors result in stability just about identical to real life states of stability. One of the most surprising findings is how very aggressive behavior by the majority often leads to a takeover by the non-aggressive types until a sort of moderate behavior rules.

Geneappears in non-fiction

For a book about genes as the architect of all evolution, this volume does a fairly poor job of defining what a gene actually is. The author even admits that the terminology is often used in a misleading way.

Genes are basically instructions for building a plant or a body or a microbe. They are strung together so scientists identify "one" gene as the section of DNA protein between a stop and start instruction. Some seem to do several jobs, and because they are strung out along the chromosome in a way we don't yet fully understand, it is difficult to tell where one gene ends and another starts. Various genes are responsible for making various proteins which grow into different organs, nerves, fluids, muscles, and so on. Dawkins's entire book is written to prove that genes that help a creature (or plant) survive and successfully reproduce will always come to outnumber failed genes that make proteins detrimental to the survival of the creature so it gets eaten or wiped out of the population. By "selfish gene", he does not mean that the gene is capable of wanting anything. He is exaggerating. But those genes which happen to behave selfishly—to do what is in their best interest—will become more common. That is, they will duplicate, reproduce, and survive at the expense of any competitor for their food or any predator that might eat them.

Because sexual reproduction in plants and animals exists, genes or parts of genes are shuffled around a great deal. A successful gene is one that has lasted a number of generations, according to Dawkins. He wants to disprove the sort of magical thinking that suggests animals and plants behave and evolve for the good of their species.

Gene Machineappears in non-fiction

It could be you, me, or the fern in the corner: any living thing is a gene machine. Dawkins does not imply that we have no free will or that we are merely puppets for greedy genes. He only means that we are the product of successful genes: genes that for whatever reason happened upon cooperative behaviors that allowed them to last.

Each cell of any individual contains a copy of all of its genes, argues Dawkins, so their survival to a new generation depends on the success of the plant or animal that they have built. The author also invites us to define plants and animals as robots controlled in a very indirect way by the genes. Some of the behaviors we engage in—for example, caring for our young—are better thought of as expressions of this tendency for genes that build bodies which behave in certain ways to survive.

Moleculesappears in non-fiction

Most people with a basic education know that a molecule is a small unit of matter consisting of electrons, protons, and neutrons, so the author does not bother to explain these principles. What he does want readers to understand or believe is that the basic, mindless attractions between molecules can logically result in organic life forms. First he verifies that simple molecular combinations when stimulated by electricity in a lab result in the building block proteins of all life. Like many other scientists, Dawkins believes this common phenomena explains the way all life on earth began. The author next imagines a soup of molecules floating around in ancient seas for millions of years with nothing to change them from one form to another. All that would need to happen is for one molecule to bond with others and to continuously repeat the process in order for the groundwork for life to be formed. There would be nothing to stop the larger one from "gobbling up" smaller ones.

Molecules do indeed bond with other molecules, creating larger ones still, in the case of crystals, for example.

Nucleotidesappears in non-fiction

The tiny molecules that make up DNA. There are only four types of these building blocks, so it is the order in which they appear and repeat that determines different qualities of a gene. As in 1976 when this book is written, many mysteries about nucleotides remain. However, more is known about the chemical makeup of nucleotides and how they form and regroup with other nucleotides.

Relatednessappears in non-fiction

Dawkins expands the idea of relatedness beyond the obvious mother daughter brother son connection to any being carrying a percentage of the same genes. By that measure, parents are not related to one at all even though they form a family in human terms. This revised thinking about relatedness starts to explain why a selfish gene machine might do something kind for its brother, for example. It's brother has a one fourth relatedness to it and a one fourth chance of eventually passing on those genes. Gene machines that nurture the brother would tend to survive and the trait of altruism to brothers would be a strong one (but probably not as strong as the gene for protecting one's self!)

Replicatorappears in non-fiction

Dawkins uses this term to describe what he imagines was the first molecule that began the cycle of life as we know it. This early molecule must have had three important qualities: it must have been able to make copies of itself, to make these copies frequently and relatively quickly, and it has to have made copies that were more often perfect than imperfect. These are the main properties of evolution, and any molecule that does not do these things eventually would be swept away by another molecule that does these things, particularly if the replicator somehow uses other organic molecules to build itself.

For example, if one replicator only makes one copy, it will be used up as food or as part of another one that spins off dozens of copies. If the copies are always quite different than the original, the original is outnumbered.

Dawkins admits that it would be unusual for such a molecule to come into existence, but over billions of years many freak things may occur. Also, once this basic building molecule had formed, there would virtually be no stopping it.

Sexappears in non-fiction

Some plants and many animals are divided into two sexes, male and female. Dawkins considers what this actually means in technical terms. After all, an eggplant doesn't have a great deal in common with a female kangaroo. The difference between male and female is that males make sperm cells and females make egg cells. Both the sperm and egg cell may contain a complete set of DNA instructions for building a plant or creature, but only half of that DNA is passed on from each parent. At first, this would make it seem that both the sperm and egg are pretty much alike, but, actually, the egg is usually larger. The sperm is sometimes more mobile. Many smaller sperm compete for each egg.

Dawkins makes all kinds of conclusions about behavior based on these observations. He says that the female often invests more in birth from the very beginning because her egg has taken more energy life force to build. It only makes sense that she should be more protective of the offspring and more choosy about the sperm she selects, according to Dawkins.

Next, when that human cell divides to make skin, bone, nerve, and so on, an exact duplicate of all forty-six new genes goes with it. This is called mitosis.

On the other hand, "meiosis" is the making inside a person (or animal or plant) of a new chromosome egg or sperm cell. This is even stranger to Dawkins, because every single sperm or egg ends up with a slightly different mix of the "pages" and "parts of pages" (genes) from the forty-six pair which came down from both parents and which instructed the body how to make itself.

Themes

The Smallest Units of Life Struggle Mindlessly to Survive.

One of the most basic principles of natural selection is that living things which successfully breed to pass on their survival advantages will begin to outnumber other things that don't—(unless those other things come up with different survival advantages). This leads to survival of a species. Many people eagerly embrace this idea. But over a hundred years after Darwin, Dawkins asks the question, "at what level of life does this push survival push originate?" In 1976, when this book is published, the question is reasonable because scientists are able to see and study tiny life forms that Darwin never could have seen and because they are able to understand DNA.

Richard Dawkins believes the survival mechanism starts at the smallest units of life that can pass on traits, or at the gene level. This seems to make sense because mindless viruses and cells that make up other animals follow the same sort of evolutionary rules complex animals and groups of animals follow. The rules of evolution must be very deep and old and primitive.

Actually, Dawkins doesn't really believe the gene itself is struggling to survive because that would mean the gene "wanted" something. His larger idea is that the ones that do happen to make superior developments do survive because they replicate successfully.

We are All Gene Machines.

The author of this book feels that plants and animals are properly described as groups of cooperative genes housed in ways that have effectively helped them survive over time. It is a strange notion, and one the author himself finds difficult to get used to. However, Dawkins, unlike Darwin, knows that genes are duplicated in every cell of a plant or body.

He has the benefit of decades of evolutionary biology which has shown how the tiniest one celled life forms have evolved into multi-celled life. By using the term "gene machine", Dawkins constantly reminds readers that even a human body is made up of many different building blocks which need to be together for a reason. By calling them gene machines, he is reminding readers of that reason: a vehicle for passing down genes.

Computer Simulation and Game Theory Help us Solve Complex Qu

In the 1970s, when this book is written, running computer models of complicated systems is a very new idea. For one thing, computers of the 1970s have very little power and memory, so complicated games and simulations are difficult to do (most of today's home computers can do hundreds of times the calculations that the best lab computers of the times could). Therefore, it is remarkable that Dawkins embraces the tool so completely.

The point of coupling game theory with running numbers by computer is that the method takes outside factors and accidents out of the equation and allows the scientist to test just one theory at a time, and quickly. The scientist says, "We think the world works like this, with these rules but we are not sure. Let's just run the rules without the distracting real world events like unfortunate accidents or fierce tigers and see if the rules we've thought up really work".

Most scientists today seem to have embraced Dawkins's thinking about building reasonable computer models to test theories. If one does not believe this, however, many of his arguments in this book fall apart. However, one would have to explain why game theory and simulation are not valid in order to be trusted by scientists.

Surprising Things Can Happen Given Millions of Years of Oppo

Probability, statistics, and odds support a great deal of what the author has to say. An event which might have a one in a million chance of occurring in one year can and probably will occur if there are billions of chances for it to happen over millions of years.

Dawkins counts on these mathematically predictable odds to explain the so-called "unexplainable". Over billions of years a replicator model might easily have accidentally formed. Perhaps multiple types of replicators might come to be. Over millions of years various mistakes and bad copies of genes might lead to changes in organisms that actually improve their ability to survive. There is no magic to the odd change or "freak accident" that cause evolutionary changes, says the author, given the vast periods of time involved.

It is as if the author is saying about life the very thing written on George Bernard Shaw's tombstone, "I knew if I hung around long enough, something like this was bound to happen".

Style

Perspective

The final chapter of "The Selfish Gene" argues that just because genes are not altruistic does not mean that we humans can't be so. With his theory of the "meme", or powerful idea that survives because of various appealing qualities, Dawkins suggests we have an opportunity to promote ideas that benefit all living beings, not just the strongest. With our human adaptation so see and plan for future events, we might be able to prevent such disasters such as overpopulation or pollution of the earth.

As in all the arguments made in his book, Dawkins defies the idea of destiny or preordained acts and urges people to use their brains in creative and nonviolent ways.

Tone

The tone of this book is chatty and friendly, with an underlying sense of self confidence. The author is presenting an idea which is very strange to readers in 1976 when the book is written, so he does his best to use simple language and a casual, conversational style that is easy to trust. Even so, he cannot seem to simplify his language down to the level of a person who knows absolutely nothing about biology. He seems to assume the reader has had at least freshmen biology classes and that they know the basic principles of evolution.

Because of this, it's difficult to tell who Dawkins expects to read this book. Is it simply a folksy, commonsense way of talking to college level scientists? After all, he drops names of other scientists whom the average reader would never have heard about. Or, is he hoping to reach a more impressionable but fairly well educated audience in order to sway popular opinion and possibly get his fellow scientists to give his ideas a closer look? It seems to be the latter. Dawkins doesn't present specific statistics or quotes from complicated scientific papers. He does work out the math probabilities in detail that wouldn't be needed for scientists used to the arithmetic.

The result is a tone that is clear and respectful but that doesn't talk down to a smart layman audience.

Structure

The structure is classic for proving a theory. The author sets out the problem or question he intends to solve, then tells readers in advance what answer he has come to. Also in the introduction, he gives the audience an overview of the various ideas that have led him to this answer. In this way, the reader will find it easy to follow the detailed steps of his thinking as the book goes along.

Following this introduction, Dawkins goes through a point-by-point explanation of the arguments that he thinks support his conclusion. At times he challenges his own theory by bringing up the work of other scientists who seem to disagree with him. As fairly as possible, Dawkins proceeds to argue against those who disagree with him.

The chapters of the book start with the oldest, most primitive behaviors of living things and work up to the most advanced behaviors. Information in early chapters support following chapters, and sometimes Dawkins hints at an idea he will talk about later in the book. From molecules to DNA, to animals to breeding, on up to advanced thinking, the author follows various points in his thinking and finally wraps it all up nicely with a summation chapter.

It is this summation chapter that is most suprising. Usually an author of this sort of scientific book reminds the readers of what he originally set out to prove, and claims he has proven it. Instead of doing this, Dawkins begins to fantasize about a world that might use his work in biology to construct a new philosophy of living.

Quotes

"We are survival machines—robot vehicles blindly programmed to preserve the selfish molecules known as genes. This is a truth which still fills me with astonishment. Though I have known it for years, I never seem to get fully used to it. One of my hopes is that I may have some success in astonishing others." Preface, page X (10)

"This book is not intended as a general advocacy of Darwinism. Instead, it will explore the consequences of the evolution theory for a particular issue. My purpose is to examine the biology of selfishness and altruism." Chap. 1, p. 1

"Even in the group of altruists, there will almost certainly be a dissenting minority who refuse to make any sacrifice. If there is just one selfish rebel, prepared to exploit the altruism of the rest, then he, by definition, is more likely than they are to survive and have children. Each of these children will tend to inherit his selfish traits. After several generations of this natural selection, the 'altruistic group' will be over-run by selfish individuals and will be indistinguishable from the selfish group." Chap. 1, p. 8

"Darwin's 'survival of the fittest' is really a special case of a more general law of survival of the stable. The universe is populated by stable things." Chap. 2, p. 13

"At some point a particularly remarkable molecule was formed by accident. We will call it the replicator. It may not necessarily have been the biggest or the most complex molecule around, but it had the extraordinary property of being able to create copies of itself." Chap. 2, p. 16

"In our picture of the replicator acting as a template or mould, we supposed it to be bathed in a soup rich in the small building block molecules necessary to make copies. But, when the replicators became numerous, building blocks must have been used up at such a rate that they became a scarce and precious resource. Different varieties or strains of replicator must have competed for them." Chap. 2, p. 21

"Four thousand million years on, what was to be the fate of the ancient replicators? They did not die out, for they are past masters of the survival arts. But do not look for them floating loose in the sea; they gave up that cavalier freedom long ago. Now they swarm in huge colonies, safe inside gigantic lumbering robots sealed off from the outside world, communicating with it by tortuous indirect routes, manipulating it by remote control. They are in you and in me; they created us, body and mind; and their preservation is the ultimate rationale for our existence." Chap. 2, p. 21

"Individuals are not stable things, they are fleeting. Chromosomes too are shuffled into oblivion like hands of cards soon after they are dealt. But the cards themselves survive the shuffling. The cards are the genes." Chap. 3, p. 37

"Survival machines began as passive receptacles for the genes, providing little more than walls to protect them from chemical warfare of their rivals and the ravages of accidental molecular bombardment. In the early days they fed on organic molecules freely available in the soup. This easy life came to an end when the organic food in the soup, which had been slowly built up under the energetic influence of centuries of sunlight was all used up. A major branch of survival machines, now called plants, started to use sunlight directly themselves to build up complex molecules form simple ones, re-enacting at a much higher speed the synthetic processes of the original soup. Another branch, now known as animals, 'discovered' how to exploit the chemical labors of the plants, either by eating them, or by eating other animals." Chap. 4, p. 49

"I have a hunch that we may come to look back on the invention of the ESS concept as one of the most important advances in evolutionary theory since Darwin. It is applicable whenever we find conflict of interest, and that means almost everywhere." Chap. 4, p. 90

"Obviously there are costs as well as benefits in laying a large number of eggs. Increased bearing is bound to be paid for in less efficient caring." Chap. 7, p. 125

"But there is more to it than this. If I am competing with my brother for a morsel of food, and if he is much younger than me so that he could benefit from the food more than I could, it might pay my genes to let him have it. An elder brother may have exactly the same grounds for altruism as a parent: in both cases, as we have seen, the relatedness is ½ and in both cases the younger individual can make better use of the resource than the elder. If I possess a gene for giving up food, there is a 50 percent chance that my baby brother contains the same gene. Although that gene has double the chance of being in my own body—100 percent, it is in my body—my need of the food may be less than half as urgent. In general, a child 'should' grab more than his share of parental investment, but only up to a point." Chap. 8, p. 138

"In general, males should tend to be more promiscuous than females. Since a female produces a limited number of eggs at a relatively slow rate, she has little to gain from having a large number of copulations with different males. A male, on the other hand, who can produce millions of sperms every day has everything to gain from as many promiscuous matings as he can snatch." Chap. 9, p. 176

"The point I am making now is that even if we look on the dark side and assume that individual man is fundamentally selfish, our conscious foresight—our capacity to simulate the future in imagination—could save us from the worst selfish excesses of the blind replicators. We have at least the mental equipment to foster our long term interests. We can see the long term benefits of participating in a 'conspiracy of doves,' and we can sit down together to discuss ways of making the conspiracy work. We have the power to defy the selfish genes of our birth and, if necessary, the selfish memes of our indoctrination. We can even discuss ways of deliberately cultivating and nurturing pure, disinterested altruism—something that has never existed before in the whole history of the world." Chap. 11, p. 215

Topics for Discussion

How much do you agree with Dawkins's theory that genes have always "run the show?" Why do you feel this way?

Did the math portion of the book make sense to you? Why or why not?

Have you ever heard the term "survival of the species?" Did you believe this was the goal of evolution? Do you think so now?

Does Dawkins's style of writing appeal to you? Is it easy to feel his enthusiasm?

How much do you really know about Darwin's theory of natural selection?

Why do you think Dawkins spent so much time discussing animal behavior instead of plant life?

What was the most surprising finding in the book to you?

Find a scientist mentioned in this book and look him/her up for more information. What was intriguing about the scientist's discoveries?

Think of an animal behavior that puzzles you. Can you construct rules for a computer game that would explain this behavior?

Did the idea of memes appeal to you? Why or why not? Are humans capable of being altruistic if we have evolved from selfish genes?