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# EVOLUTION’S ARROW

The Direction of Evolution and the Future of Humanity

The Chapman Press

First published in 2000 by The Chapman Press, PO Box 76 Rivett, Canberra, 2611 Australia.



**National Library of Australia Cataloguing-in-publication data:**

Stewart, John, 1952 Nov. 27-
Evolution's Arrow : the direction of evolution and the future of humanity.

Bibliography.
Includes index.
ISBN 0 646 39497 5.

1. Evolution. 2. Human evolution. I. Title.

599.938

Printed in Australia by Ausdoc on Demand, Canberra

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# PART 1

# Evolutionary Progress?

# 1

# Introduction

The emergence of organisms who are conscious of the direction of evolution is one of the most important steps in the evolution of life on any planet. Once organisms discover the direction of evolution, they can use it to guide their own evolution. If they know where evolution is going, they can work out what will produce success in the future, and use this to plan how they will evolve.

Living things can evolve without having any knowledge of the direction of evolution. The diversity and complexity of life on earth is testimony to that. Organisms can try to deal with the future by blindly making changes to themselves or their offspring and seeing how the changes work out in practice. But this takes a lot of costly trial-and-error, particularly when the future is complex or changes rapidly. It is a bit like trying to drive a car through peak-hour traffic blindfolded. It will not be a winning strategy for organisms whose competitors can predict future events and use this to evolve more effectively.

The alternative is for organisms to guide their evolution by forming a picture of how evolution is likely to unfold in the future. They can try to find trends and patterns in this evolution that might impact on their future chances of survival. They can then use these patterns to see how they must change themselves and the way they are organised in order to continue to be successful.

On this planet, the organism that appears likely to take this significant evolutionary step is us. Our growing understanding of evolution is providing us with the knowledge that will enable us to see that there are large-scale patterns in the evolution of life. And it is a short step from this to recognising the evolutionary significance of using these patterns to guide our own evolution. But this significant step will not be possible until we have developed a comprehensive understanding of the direction of evolution and of its implications for humanity. The development of this theory will itself be an important step in our evolution. Key issues that it will have to address include:

- what is the direction of evolution? Where is it headed? Is the direction of change progressive, in the sense that life advances and improves as evolution unfolds? If it does progress, in what way do organisms improve?
- where does humanity fit in? Are we to be like the dinosaurs, better than what has gone before us, but

soon to be replaced by something superior? Or can we play a significant role in the future evolution of life in the universe?

- what choices do we have? If we can see where evolution is going, is it possible for us to change to fit in with the direction, so that we can survive to participate in the next steps in evolution? Or should we ignore the direction of evolution, and live our lives in ways that might make us irrelevant to future evolution? Can we turn our back on the evolutionary processes that have produced us?
- what does this mean for us as individuals, here and now, for the way we live our lives and the way we organise ourselves socially? If we decide to do what we can to ensure that humanity participates in the future progressive evolution of life in the universe, what do we have to do, individually and collectively? Will we have to change our economic and social systems? Our psychology?
- Can deeper understandings of evolution and of its direction assist in answering the ancient questions that confront all aware human beings: where do we come from? what are we? where are we going to? Is there a purpose to human existence?

These are the central themes of this book.

In the chapters that follow, I will argue that evolution has direction, and that the direction is progressive. I will also show that this direction is important in answering the fundamental question of how we should live our lives. Awareness of the direction of evolution is capable of providing direction to our lives and for humanity as a whole.

To clear up one point of possible confusion immediately, I will be showing that evolutionary change progresses in evolutionary terms, not in human terms. Organisms improve as evolution unfolds in the sense that they become more competitive and better adapted than those they replace. They get better at surviving. But they will not necessarily get better against criteria that are important to humans. For example, the competitiveness of an animal might increase if it develops the ability to physically terrorise other members of its species to get a greater share of food. This would be an improvement in evolutionary terms, but many of us would not consider it to be progress in human terms[1].

This distinction is particularly clear in human evolution. The idea that human society progresses has taken a battering in the 20th century. We have seen the largest scale wars in human history. Six million Jews and twenty million Russians died in the Second World War alone. And modern societies have not necessarily produced better lives for their citizens. Members of earlier tribal societies arguably experienced happier and more meaningful lives than members of technologically advanced nations.

Much change in human society has not been progressive in human terms. But this does not mean humanity has failed to progress in evolutionary terms. Most of us now live in nation states that have proved their evolutionary superiority to tribal societies by replacing them over most of the planet.

There is a further important difference between these two different types of progress. The criteria used to assess whether evolutionary progress has occurred in any instance are objective. If organisms have improved their competitiveness and their adaptive fit to their environment, they have progressed in evolutionary terms. This may be difficult to assess in practice. But it is not fundamentally subjective like deciding the criteria that should be used to assess whether change is progressive in human terms. There are as many ways of defining progress in human terms as there are different sets of human values.

Our ability to assess objectively whether evolution progresses does not mean the issue is free of controversy. Evolutionists do not currently agree on whether evolution is progressive. Most believe it is not. The view that evolution is progressive and that humans are now at the leading edge of evolution on this planet is not supported by most evolutionary thinkers[2]. A major task of this book will be to show that they are wrong.

Progressionist ideas about evolution were popular until the middle of this century[3], but have since come under increasing attack. This is largely because progressionists have been unable to identify any plausible evolutionary mechanism that would continually drive progressive change along some absolute scale.

Anti-progressionists such as the noted American evolutionary writer Stephen Jay Gould argue that there is no such mechanism. They say that current evolutionary theory does not include any process that would produce general and on-going improvement as life evolves[4]. Natural selection adapts populations of organisms only to the specific local circumstances encountered by each population. This may produce some short-term improvement and directional change as the organism adapts better to local conditions, or as the environment changes. For example, a population of snow hares might progressively evolve thicker fur if average winter temperatures increase from year to year. But the directional change will end when the opportunity for improvements in local adaptations is exhausted, or when the local environment changes again in some other direction. And, Gould argues, better adaptation to local conditions will not produce general advance or progress. Changes that adapt a particular organism to its specific environment would not improve it for many other environments. A fish has no use for a better wing, or a bird for more efficient gills. Gould cannot envisage improvements that would be better in all conditions.

Gould and his supporters conclude that the earlier enthusiasm for progressionist views has no sound evolutionary basis: there is no mechanism within evolution that drives on-going progress; natural selection is a process that produces only local adaptation, not general advance or progress; and both the fossil record and the pattern of life we see about us are consistent with this. According to Gould, the belief that humans are at the leading edge of evolution is best explained as wishful thinking.

Progressionist views are currently in a similar position to evolutionary ideas prior to Darwin's *The Origin of Species*. In the centuries before Darwin, many thinkers had come up with the idea that some form of evolution best explained the pattern of plants, animals and fossils they saw in nature[5]. But they could not identify a plausible mechanism that explained how this evolution could occur. Evolutionists prior to Darwin could demonstrate that some aspects of the pattern of nature were consistent with evolution, but this consistency could easily be dismissed as lacking any causal basis. Like patterns of stars in the night sky that resemble shapes significant to humans, the consistencies could be dismissed as the product of creative imagination, not the result of real, causal relationships.

Darwin's great contribution was not the idea of evolution. It was to identify natural selection as the cause of evolution, and to demonstrate that natural selection was the inevitable result of sequences of tangible, concrete events in nature. He showed that evolution would occur wherever some organisms were more successful than others due to differences that could be passed to their offspring.

If progressionist views are to gain the widespread acceptance achieved by evolutionary theory, progressionists have to meet the challenge of identifying a concrete, causal basis for evolutionary progress. Without this, it is not possible to distinguish between patterns and trends that are accidental and meaningless, and those that are necessary and real. A central task of this book is to meet this challenge by showing that evolution includes processes that drive it in a particular direction, and that the direction is progressive.

I will show that the direction of evolution is towards increasing cooperation between living organisms. As evolution proceeds, living things will increasingly coordinate their actions for the benefit of the group rather than acting only in their own individual interests. Cooperators will inherit the earth, and eventually the universe[6].

Part Two of this book (Chapters 3 to 7 inclusive) is devoted to demonstrating that evolution is progressive, and that it produces increasing cooperation amongst living processes. Part of the argument in favour of this position is not controversial: it is beyond doubt that cooperation can be efficient and effective in evolutionary terms. Whatever challenges organisms face during their evolution, the challenges can be met more effectively through cooperation.

But how can evolution progress by exploiting these benefits of cooperation when, as Richard Dawkins and others have shown so clearly[7], evolution favours organisms that put their own selfish interests above all else? We will see that there is a solution to this apparent paradox: cooperation can flourish without organisms giving up their self-interest. Organisms can be organised so that beneficial cooperation is also consistent with their self-interest. When organisms are organised in this way, it is in their interests to be cooperative.

Within such an organisation, individuals will benefit when they cooperate, and will be harmed if they hurt the organisation. An example is a human business that is organised so that employees who work together to develop a new product obtain a share in any profit or loss it produces. In a group organised in this way, individuals who follow their own interests will also generally serve the interests of the group. Wherever cooperation pays off for the group, cooperation will generally also be in the interests of its members.

Evolution progresses towards greater cooperation by discovering ways to build cooperative organisations out of components that are self-interested. It has done so repeatedly throughout the history of life on earth. Cooperative groups of self-replicating molecular processes formed the first simple cells, groups of these cells formed larger and more complex cells, these in turn formed cooperative groups of cells that became multicellular organisms, and groups of multicellular organisms formed cooperative insect societies and human social systems.

One thing that is striking about this is that the cooperative groups that arose at each step in the sequence became the organisms that then teamed up to form the cooperative groups (and organisms) at the next step in the sequence. The result has been that all larger-scale living organisms are made up of smaller-scale living processes that are in turn made up of still smaller-scale processes and so on. And for the organism to operate effectively, all these layers of living processes must cooperate in the interests of the organism. All organisms, each of us included, are cooperative organisations.

It is also obvious that this sequence has direction. As the sequence has unfolded, the scale over which living processes cooperate has increased. In the evolution of life on this planet, cooperation between living processes began over very small scales and has progressively increased through the formation of larger and larger-scale cooperative groups and organisms. And in the last 10,000 years, this trend has accelerated enormously. Cooperative human groups have increased in scale from small tribal societies to nation states and empires, and now to forms of human organisation that operate on the scale of the planet (e.g. multinational companies, and economic markets).

Three thousand million years ago, cooperation extended only between molecular processes that were separated by about a millionth of a metre, the scale of early cells. Now, cooperation extends between human organisms that are separated by up to 12 million metres, the scale of the planet. And by up to 380 million metres when there are moon landings. Cooperation between molecular processes and cells now also extends over these larger scales. When humans cooperate in world-wide economic activities, so do their cells. And these increases in the scale of cooperation are unlikely to end here and now. The same evolutionary forces that drove the expansion of cooperative organisation in the past can be expected to continue to do so.

We will see that evolution progresses towards increasing cooperation whatever the mechanism that produces evolutionary change in organisms. As long as the mechanism is good enough at finding better adaptation, it will discover and exploit the benefits of cooperation. Both natural selection and the processes that produce cultural evolution in humans produce progressive evolution. Furthermore, the advantages of cooperation can be expected to drive progressive evolution wherever life emerges. On any planet where life evolves, evolution can be expected to produce cooperation over wider and wider scales, as it has on earth.

To exploit the benefits of cooperation effectively, groups of entities must evolve an ability to discover the most useful forms of cooperation, and to modify them as conditions change. They must be able to evolve and adapt their cooperation. The better and quicker they are at discovering effective cooperation, the better they will do in evolutionary terms. Imagine the evolutionary success enjoyed by the first groups of molecular processes to discover how to cooperate to construct a cellular membrane, the first groups of cells to produce a network of nerves to coordinate their activities, and the first groups of humans to learn how to chase game animals off cliffs.

So it is not only through increases in cooperation that evolution progresses. It also progresses through increases in the ability of living processes to adapt and evolve. The advantages of being better at adapting have driven progressive improvements in the evolvability and adaptability of cooperative groups, and of the organisms they eventually produce. The processes that adapt and evolve organisms have got progressively better at discovering the most effective forms of cooperation amongst the living processes that make up the organisms. Evolution itself evolves, and living processes get smarter at evolving.

Part Three of the book (Chapters 8 to 12 inclusive) deals with this evolution of the processes that adapt and evolve living processes. We will see how progressive evolution has improved the ability of the genetic evolutionary mechanism itself to adapt organisms[8]. The genetic mechanism uses trial-and-error to search for better adaptation. It tries out genetic changes when offspring are produced. If a change improves the ability of an offspring to survive and reproduce, it spreads throughout the population, producing organisms that are better adapted.

If these genetic changes are made randomly, the majority will be harmful. Most changes made blindly to a complex organism will kill it. Random change is a very inefficient way to search for improvements. So a genetic mechanism that can target its changes will have an evolutionary advantage. It can cut down on the number of changes that are harmful, and make changes that have a greater chance of being useful. For example, a population of snow hares in an environment in which general temperatures are changing widely every few years could target its genetic changes at varying the thickness of fur. This would be more likely to pay off than changing genes that are unrelated to environmental changes. A genetic mechanism that can focus genetic change in this way would be more efficient at discovering better adaptation. We will see that important features of genetic systems have evolved to target genetic change. We will see that sexual reproduction itself owes its existence to its ability to do this. Sex is smart[9].

But improvements in the genetic evolutionary mechanism can go only so far in enhancing the ability of organisms to adapt and evolve. The genetic mechanism can try out changes and discover better adaptation only when organisms reproduce. It cannot search for improvements during the life of the organism. Entirely new adaptive and evolutionary mechanisms had to be developed to exploit the great advantages of doing this. The new mechanisms had to be able to try out and test changes within the organism during its life[10]. Cells, multicellular organisms and human societies have all evolved internal processes that discover new and better adaptation in this way. Typical examples are our own physiological, emotional and mental adaptive systems.

We will see how the advantages of smarter adaptability and evolvability have driven a long sequence of improvements in these internal adaptive processes. A key milestone was reached when organisms could communicate with each other about adaptive improvements they had discovered during their lives. Adaptive discoveries no longer died with the individual who made them. They could be passed on to others, and a culture of adaptive information could be developed. Once this ability evolved, the internal adaptive processes qualified as evolutionary mechanisms, able to accumulate adaptive discoveries across the generations. On this planet, only humans and our societies have evolved this capacity to a high level.

A further key milestone in the progressive improvement of evolvability was the development of a capacity for mental modelling. Again, on this planet only humans have fully developed this ability. An organism capable of mental modelling can form internal mental models and mental pictures of how its environment will unfold in the future, and how its actions will affect this. To an extent, it can predict the future. So it is able to try out possible actions mentally, select the one that produces the best future result in its mental models, and only then try it out in practice[11]. It will be able to use its mental models to see how to manipulate its environment to achieve its particular objectives.

Over the generations, organisms with this capacity can collect more and more knowledge about their environment and the effects of their actions. This will enable them to build mental models of their environment that are more comprehensive and accurate. Progressively the organisms will be able to model how their environment unfolds over wider and wider scales of space and time. Eventually the organisms will be able to model the wider-scale evolutionary processes that have produced it and will affect them in the future. For the first time they will see themselves as situated at a particular point in an on-going and progressive evolutionary process. And they will not just become aware of the direction of evolution. They will also become aware that their increasing awareness of the direction of evolution is itself a significant step in evolution.

The organisms will see that their existing physical adaptations and their existing motivations, interests, beliefs, and values are all the products of their evolutionary history. These characteristics will have all been tailored and tuned by past evolution to ensure that the organism survives. As their understanding of the direction of evolution improves, they will also see what they will have to do in the future to continue their evolutionary success. The organisms will see what they have to do both as individuals and socially: they will understand that they must further exploit the benefits of cooperation by forming cooperative organisations of larger and larger scale and greater and greater evolvability.

But will the organisms use their awareness of the direction of evolution to guide their own evolution? Will they choose to do what is necessary for future evolutionary success? Will they care about their evolutionary future? The difficulty faced by all organisms at this stage in their evolution is that they will be unlikely to find satisfaction and motivation in what they have to do for future evolutionary success. Continued success will demand radical changes in their behaviour and social organisation. But their existing motivations, moral codes, and values will influence their willingness to make these changes. The problem is that their motivations and other predispositions will have been moulded by the needs of past evolution, not future evolution. Past evolution will have tailored their motivations and values so that they find satisfaction in behaviours and actions that would have produced success in the past, not those that will produce success in the future. Up until the development of their capacity for mental modelling, they will have been adapted by evolutionary mechanisms that were without foresight, and could not take into account the needs of future evolution.

It is one thing for an organism to know what it has to do for future evolutionary success. It is another thing entirely to want to do something about it. It is a bit like a person who knows that it is in his longer-term interests to work long hours and save money while he is young to provide for a comfortable retirement. As many of us know, awareness of our longer-term interests will not automatically motivate us to do what is necessary to serve those interests. The difficulty in finding motivation to pursue future evolutionary success is even greater. The individual will often not benefit at all through support for evolutionary objectives. It will often be only future generations who do so.

A better understanding of this difficulty can be had by imagining the following scenario: you are able to travel back in time, and you have been given the job of going back 50,000 years to show a band of human hunter-gatherers how they must change to achieve future evolutionary success. You are to use your knowledge of how evolution has unfolded since then to get them to change in the ways necessary for them for future success. How likely are you to get them to change? Would they freely choose to reorganise themselves in the ways that have proven successful for human groups since then? For example, would they want to band together with other tribes, give up their nomadic way of life, give up hunting and instead grow crops? Would they accept being ruled by a king who would collect taxes from them and use these to fund irrigation schemes and an army, as well as a personal lifestyle befitting a king?

If they could have chosen to change their behaviour and organise themselves in this way 50,000 years ago, they would have a good chance of founding an empire that had a lasting impact on human history and evolution. But to do so would mean acting contrary to their most fundamental beliefs about how they should behave as members of their band.

Based on our experience of the few hunter-gatherer tribes that have survived until recently, many of their attitudes, values and moral beliefs would have clashed with the changes needed to progress in evolutionary terms[12]. In hunter-gatherer bands, a man could not be respected if he did not hunt. A male who wanted to plant and tend crops would be despised. The members of other tribes were often seen as sub humans who had to be driven out of the tribe's territory before they stole their game and women. To band together with them would be unthinkable. And anyone who tried to set himself up above the other members of the tribe as a ruler would be seen as a threat to all, and to be stopped at all costs. Anything gathered by an individual was not his or hers, it was the tribes'. Only a deviant would try to accumulate possessions. And deviants were seen as a danger to the band who should be expelled if they did not change their ways.

Such a band would have very little capacity to change its fundamental values and beliefs, and little desire to do so. The members of the band would not have the psychological ability to find motivation and satisfaction in whatever behaviour and life style was needed for future evolutionary success. Merely showing them how things would evolve in the next 50,000 years would not enable them to change their ways. They would continue to find satisfaction in their existing way of life.

But we will see that an organism that develops a fuller understanding of the evolutionary process and of its place in it will be more likely to break free of its biological and social past, and develop the capacity to do whatever is necessary for future success. Such an organism will become aware that its existing beliefs, motivations and values have no special validity. It knows that if its past evolutionary needs were different, its motivations and values would also be different. These predispositions will be seen as the products of shortsighted evolutionary mechanisms that have been incapable of producing the motivations and values needed for future evolutionary success.

The organism will know that all organisms that develop the capacity to mentally model their possible evolutionary futures face a common challenge: to find motivation and satisfaction in whatever actions and behaviours are shown by their models to bring future evolutionary success. The challenge is not only to see what is needed for future evolutionary success, but also to be able to do it. Where necessary, they must cease to serve the beliefs, values and objectives established by their evolutionary past. They must develop the psychological capacity to change their nature. They must be able to change as much as the first cells had to change to produce multicellular organisms. And they must be able to do this not just once, twice, or three times, but whenever necessary.

If they can develop this psychological capacity to adapt their behaviour in whatever way is necessary, they can transcend their biological and social past. They can become self-evolving beings, able to change their behaviour and objectives by conscious choice. They will see themselves as evolutionary work-in-progress, with no fixed characteristics, able to find satisfaction and motivation in doing whatever they choose.

The organism will also know that only organisms that choose to struggle to develop this psychological capacity are likely to make a significant contribution to the future evolution of life in the universe. Those who choose instead to continue to serve obsolete values and motivations will be irrelevant to life, and face eventual extinction. The organism will know that the choice that faces it is, in an evolutionary sense, a choice to be or not to be.

In Chapters 11 and 12 we will look at how organisms such as ourselves are likely to develop this psychological capacity. We will see that an organism can use its modelling capacity not only to model and manage its external environment, but also to model and manage its internal adaptive processes. It can develop mental models of the pre-existing physical, emotional, and mental adaptive processes that determine how it behaves and acts. The models will enable it to understand consciously how its pre-existing adaptive processes operate, what useful effects they have, how they might be modified, and what the consequences of this might be. Through self-knowledge they will develop the capacity to gain control over their internal adaptive processes. Increasingly, this will enable them to manage their physical actions, emotional and motivational states, and their beliefs and other mental processes in whatever ways are necessary to ensure they can do what is required for future evolutionary success. They will develop a capacity for self-management that enables them to revise and modify their previous motivations, beliefs and objectives. These will be revised and managed so that they support the ultimate objective of future evolutionary success[13].

Part Four of the book (Chapters 13 to 19 inclusive) uses the ideas about evolutionary progress developed in earlier Chapters to understand the evolution of life on earth. These Chapters identify key evolutionary milestones since life emerged on this planet 3,500 million years ago, and predict important future milestones. A major focus is how human cooperative organisation has evolved, and how it is likely to evolve in the future.

Cooperation camongst humans has expanded considerably in scale over the past 100,000 years. Initially cooperation existed only within small family groups. Since then, cooperative organisation has progressively expanded in scale to produce multi-family bands, tribes, agricultural communities, cities, empires, nation states, and now some forms of economic and social organisation that span the globe[14].

We will see that not only has the scale of cooperative organisation expanded rapidly, but so too has its evolvability. Human societies have got better at discovering and supporting more effective cooperation, and at adapting it as circumstances change. Modern human societies can adapt and evolve continuously through internal processes during their life. They are not limited to evolving through competition and natural selection between societies.

But the ability of human cooperative organisation to exploit the benefits of cooperation can be greatly improved. Modern human societies are obviously not an endpoint of evolution. The organisms that play a significant role in the evolution of life in the universe will not be those that stop evolving when they reach the position we have. Guided by awareness of evolution's arrow, they will go on to form cooperative organisations of larger and larger scale and of greater and greater evolvability. First they will form a unified planetary organisation that manages the matter, energy and living processes of the planet. Then this organisation will be progressively expanded to form still larger-scale societies of increasing evolvability. Matter, energy and life will be managed on the scale of the organism's solar system and, eventually, its galaxy. The greater the scale of the resources the organism is able to manage, the more likely it will be able to adapt to whatever challenges it faces in its conscious pursuit of future evolutionary success.

We will look at how modern human societies could be changed to improve their ability to organise cooperation to satisfy the needs of their members. Economic markets and governments are the main processes in current societies that support and adapt large-scale cooperation. We will see how these processes could be improved to produce human societies that are more evolvable and better at exploiting the benefits of cooperation. These improvements would establish a highly evolvable and cooperative planetary society. They would produce benefits for all humanity by suppressing conflict and other damaging competition within the society, and by efficiently organising cooperation to serve the needs and objectives of citizens.

But, by themselves, these changes would not establish a society that would consciously pursue future evolutionary success. The society would not achieve the critical evolutionary milestone of using the direction of evolution to guide its future evolution. This is because the society would satisfy the needs and objectives of its citizens, whatever they may be. Until its citizens chose to consciously pursue future evolutionary success, the society would therefore continue to serve only the pre-existing biological and cultural needs of its members. The immense evolutionary potential of a society that could intelligently manage matter, energy and life on the scale of the planet would be used to serve values and objectives established by shortsighted and flawed evolutionary mechanisms. The enormous power of our emerging technologies such as artificial intelligence and genetic engineering would not be harnessed to achieve future evolutionary success. Instead they would be used merely to satisfy obsolete desires and values that conflict with future evolutionary needs.

But this would all change once humans become aware of the direction of evolution and develop the capacity to use it to guide their own future evolution. As humans begin to pursue future evolutionary success consciously and learn how to align their personal values with this objective, they would produce a planetary society that also pursued evolutionary ends. Because the planetary society would manage matter, energy and life to serve the needs and values of its members, it would serve their evolutionary objectives. The society as a whole would develop plans, strategies, projects and goals designed to maximise its contribution to the successful evolution of life in the universe. And it would organise itself to reward and support actions of its members that assisted the society to achieve its goals—just as our bodies reward and support the actions of individual cells that contribute to meeting the body's adaptive objectives.

Finally, we will look at what all this means for each of us as individuals, here and now. We will see that a full understanding of evolution and its direction leaves an individual with very limited choices. It is not open to us to choose to ignore the dictates of evolution. Whether we choose to pursue only the values and motivations established in us by our biological and cultural past, or instead decide consciously to serve the future evolutionary interests of humanity, we will be following evolutionary objectives. The only choice is between serving goals established in us by evolutionary mechanisms that are incompetent, or by mechanisms that are the best available. We can choose to live a life that serves obsolete evolutionary goals established by inferior and shortsighted evolutionary mechanisms. Or we can use awareness of the direction of evolution to guide how we can consciously contribute to the future evolutionary success of humanity.

Once individuals become aware of the direction of evolution, if they decide to continue to serve the dictates of past evolution they are choosing evolutionary failure, in the full knowledge that they are doing so. Individuals that make such a decision are choosing a life that is meaningless, absurd and ridiculous from an evolutionary perspective, and know that they are making such a choice.

Individuals who instead use the direction of evolution to guide their actions obtain a clear answer to one of the most central questions of their existence: "What should I do with my life?" They see that they should do what they can to promote the awareness of the direction of evolution amongst others and to develop in themselves and in others the psychological capacity to do what is necessary for future evolutionary success. They will also want to contribute to the formation of a cooperative and evolvable planetary society that manages the matter, energy and living processes of the planet to form organisations of yet larger scale and of greater evolvability. And they will be aware that their actions are contributing to the next great step in the evolution of life on earth.

One of the most important steps in the evolution of life on any planet is the emergence of organisms who are conscious of the direction of evolution and who use this to guide their own evolution. The actions of individuals who are living now can help ensure that the organism that achieves this milestone on earth will be us.

# 2

# The Causes of Progress

What do I have to do to show that evolution is progressive? If I am to prove that evolution continually improves living processes in some general direction, what must I show about the evolutionary process?

One way to attack these questions is to examine a process that is clearly progressive to discover the type of mechanism that drives progress. Then we can see if the process of evolution also contains such a mechanism. If it does, we may be able to use an understanding of the mechanism to see where it is taking the evolution of life.

One of the areas that shows obvious progressive change is human technology. Technologies that serve key areas of human need such as communication, transport, and lighting have shown long trends of improvement in performance. Completely new and improved technologies have repeatedly emerged in each of these areas. Electric lighting is more efficient and convenient than gas lighting, which in turn is cleaner and more effective that lamps that burn mineral oil or animal fats. Aircraft are more efficient at some transport tasks than railways, which in turn have proved more useful than vehicles hauled by animals. And each century has seen new ways for humans to die in war.

As well as through the discovery of completely new technologies, technology also progresses incrementally. Each successful technology usually shows long sequences of improvement in performance as it is developed. The motorcar of the 1990's is faster, more reliable, and relatively cheaper than cars of the 1920's.

The case that technological change can be progressive is overwhelming[1]. Even strong opponents of the progressive view of evolution generally accept that technological change can be progressive[2]. But what is it that causes progressive technological change? What features of the processes that cause technological change are responsible for progressive improvement? And does the evolutionary process share these features?

Two features seem to be essential if a process is to produce progressive change. First, it must contain a mechanism that searches for improvements and reproduces any that are discovered. In the case of technological change, it is our mental processes that search for improvements. Individuals and groups are continually looking for new possibilities, trying to invent new technologies or to improve existing ones. Whether any particular discovery is reproduced depends on the extent to which it attracts sufficient interest in the economic or political marketplace. Of all the innovations thrown up by inventive minds, the market selects those that will be reproduced. Technology improves by being better able to satisfy the needs of individuals and groups who have economic or other power in these markets.

Second, a process that searches for innovation will produce progressive change only if there is potential for improvement. This potential must be on-going and not be exhausted immediately by the mechanism that searches for innovation. If the potential improvements can be discovered and implemented right away, they will not drive a sequence of progressive change. Obviously, motorcars would not have been improved throughout this century if there had been no potential for on-going improvements, or if all possible advances and supporting technologies had been discovered soon after cars were first developed.

Progress will occur if the potential improvements are discovered in a series of steps, with each step improving on previous steps, but leaving potential for further improvement that will drive further discovery. This will be the case where improvements necessarily build on previous steps, and are able to be made only after the previous steps have been taken. An example is the development of electronic monitoring and regulatory systems in car engines that had to await the emergence of computer technology, that in turn was not possible before improvements in semiconductors.

The pattern of change will also have this structure where better technologies are more complex, or where their development requires comprehensive and detailed research. The simpler technologies will generally be discovered and implemented earlier than more complex ones. For example, the first motorcars and aeroplanes were far less complex than those we see today, and improved versions that are even more complex are likely in the future.

We can therefore expect progressive change wherever it can be shown that there is a potential for improvement that is on-going in this sense. Provided the mechanism that searches for improvements is smart enough to take advantage of the potential for improvement, and not so smart that it discovers them all at once, progressive change will be produced.

With the benefit of hindsight we can see that technology has progressed where there has been potential for on-going improvements, although the potentials were often not obvious beforehand. It is not so easy to show exactly where there will be technological progress in the future. To do so we would need to identify where there are on-going potentials for technological improvement. The difficulties in doing so are notorious. In the middle of the 19th century, engineers could prove beyond doubt that flight by heavier-than-air machines is impossible. Nevertheless, assessments of where there is potential for improvement are made as a matter of course in the planning of research strategies. And where the potential exists, progress can be reasonably predicted.

Other processes will also produce progressive change if they have these two key features—a search mechanism that discovers and reproduces improvements, and potential for on-going improvement. For example, the processes that develop skills in children often have both these features. Children search for new ways of doing things that will improve their skills, often with the help of parents and teachers. Changes are reproduced when they rewarded by success. And it is obvious to all of us who have previously mastered new skills that there is often an ascending scale of potential improvements that will drive progressive change. As a result, children progressively improve their skills as they grow and learn.

This is particularly clear in learning a musical skill such as piano playing, where each improvement necessarily builds on previous ones. There is a sequence of potential improvements in playing ability, with each improvement building on the skills gained earlier. We therefore can predict confidently that if a child has the will and ability to learn (i.e. an adequate search mechanism) progressive improvement will follow.

Unless a process contains both of these key features in full, change will not be progressive. For example, there is obvious potential for on-going improvement in the ability of human society to satisfy the needs and to develop the potential of its members. Technological progress has opened up the potential to improve the living standards of all people on this planet. But this potential for social improvement has not been fully exploited this century. It has not driven on-going social progress. Instead, at the end of the

20th century over 800 million people are chronically undernourished, and each year nearly 13 million under fives die as a direct or indirect result of hunger and malnutrition[3]. In industrialised countries, many people spend much of their lives in unsatisfying, boring and meaningless work, while large numbers choose drugs over reality.

Human society has failed to produce on-going social progress in these areas because it does not include a mechanism that selects and reproduces social improvements when they are discovered or proposed. If society stumbles on improvements either by accident or by conscious effort, there is no process that locks in the improvements and perpetuates them. The economic and political markets that select and reproduce technological advances do not do the same for social improvements.

As we shall consider in detail later in this book, it is possible to organise human society so that social improvements are selected and reproduced, and so that social progress is as inevitable, unstoppable and natural as technological progress. And we will see that evolutionary success for humanity will ultimately depend on organising ourselves in this way.

This discussion has now got us to the point where we know what must be done to show that evolution is progressive. First we must show that the evolutionary process contains mechanisms with the ability to search for improvements in living processes and to reproduce any that are discovered. Second we must show that there are potentials for improvement in living processes that are on-going.

It seems certain that any process that successfully evolves living processes must meet the first condition. The central feature of an evolutionary process is that it searches for useful changes in living things, and reproduces improvements from generation to generation. If a process is capable of producing evolutionary change in living processes, it must contain a mechanism that searches for improvements and reproduces any that are discovered.

The most familiar evolutionary mechanism, natural selection acting on genetic variation, clearly meets this condition. Animals produce young that may vary genetically from their parents because of mutations or different combinations of genes. If the variants prove to be better adapted because of their different genes, they are likely to have relatively more offspring, with the new genes eventually taking over the population. In short, this process searches for improvements by throwing up genetic variants, and then perpetuates any improvements that are discovered.

The fact that the genetic mechanism searches for improvements largely by blind trial-and-error does not prevent it from producing progressive evolution. If there are potentials for on-going improvement and if it can stumble on them, it will produce progressive change. It does not matter that the genetic mechanism has no foresight or intention to make progressive discoveries.

Although nearly all living organisms known to man evolve through the genetic mechanism, it is not the only mechanism that produces evolution. There are other evolutionary mechanisms that search for better adaptations in living processes, and reproduce the improvements from generation to generation. A number of the processes which adapt humans as individuals provide obvious examples. As individuals, we continually use our mental processes to search for better ways of adapting to our circumstances, better ways to stay healthy, to prolong our lives, and to satisfy our needs. Often assisted by others, we develop and test possible adaptations mentally, select those that we think will work, try them out in practice, and adopt those that are best for us. When a successful improvement is discovered, it is likely to be adopted by others. If so, it will be reproduced throughout the population. It will be preserved across the generations until it to is replaced by something better. The result is an evolving culture of adaptive knowledge.

Change produced in this way is as much evolution as is genetic change produced by natural selection[4]. When humans discovered how to build aircraft, and passed the ability from generation to generation, the result was evolutionary change. It was as much evolutionary change as the discovery by natural selection of wings in the first birds, and the passing of the relevant genes from generation to generation. The mechanisms that discovered and reproduced each of these types of change were different, but the end result was the same: evolutionary adaptation.

In humans, the processes that adapt individuals are not the only evolutionary mechanisms. Other mechanisms adapt human societies and organisations. The processes that adapt the cells within our bodies also fall into two classes. One class adapts individual cells, and the other adapts the organisations of cells that form tissues, organs, and the body as a whole. And in ant colonies, some processes adapt individual ants, and supra-individual processes adapt groups of ants and the colony as a whole.

In the case of the mechanisms that adapt individuals, possible improvements are developed, tried out, and selected at the level of the individual human, cell or ant. But in the case of organisational adaptation, it is the collective activity of many individual humans, cells or ants that search for and reproduce adaptations. Through these processes the organisation can solve adaptive problems collectively that individuals cannot. Just as our brain solves problems that are not understood by any cell in the brain, human markets and governments can solve adaptive problems that are not fully understood by any individual.

We will deal in detail later with the evolution of these various evolutionary mechanisms. We will look at what has driven the evolution of new mechanisms and how each mechanism has evolved and got smarter at evolving. Then we will consider how the mechanisms that currently evolve human individuals and human societies will evolve and improve in the future.

However, what is clear already is that the processes that produce evolutionary change each include a search mechanism. But this by itself is not enough to prove that evolution is progressive. We must also show that there are potentials for improvement in living things that are on-going and that can be exploited by the search mechanisms.

Are there on-going potentials for improvement in living things? Will an evolutionary search mechanism that is smart enough discover a sequence of changes, each better than the one before, and each an improvement in purely evolutionary terms?

Once it is accepted that evolution includes adaptive change in human culture and society, we can immediately point to an area where potentials for on-going improvement exist and have driven progressive evolutionary change: human technology. As we have seen, technological change is often progressive, producing sequences of improvements, each step better at satisfying human needs than those before. And it can be shown that there is further on-going potential for improvement in many areas of technology that will drive further progressive change.

We can go a step further by noting the general similarity between human technology and the bodily features of organisms that adapt them to their external environment. We often use our technology to adapt to our external environment. But most organisms achieve this through specialised features of their bodies such as legs, wings, fins, eyes, gills and lungs. The technology that enables them to move, see and communicate is part of their bodies.

Because of this general similarity, we can expect that the potentials for on-going improvement that have driven technological progress will also exist for the bodily technology that adapts organisms to their environment. And our experience with technological progress points to where these on-going potentials will be most pronounced. They will be most obvious in the evolution of complex adaptations such as the eye where a number of components need to cooperate together to make the adaptation effective. Evolution is unlikely to be able to perfect these complex adaptations in one step. Instead we would expect that the adaptation would be improved in a series of steps as new components are added and developed, and as components are adjusted to changes in other components[5].

These sequences can be expected to be most noticeable where the improvements are chasing better adaptation to environmental conditions (living or non-living) that are themselves changing. The most obvious examples are ‘arms races’ between predators and their prey: the predator evolves greater speed, the prey counters by increasing its evasive ability, the predator responds with improvements in its ability to anticipate the movements of the prey, and so on[6].

The fossil record, where it is good enough, confirms the expected progressive evolution of complex adaptations. A particularly clear case is the evolution of warm-bloodedness in the ancestors of mammals. An ability to continually maintain the warm body temperatures that are best for movement and other activity has significant advantages. Cold-blooded reptiles are unable to do this, so they need to wait for warm air temperatures and the sun if they are to get to a temperature that is best for active movement. Early warm-blooded mammals could be out feeding all night while cold-blooded reptiles waited for the sun.

Complex changes to the blood system, physiology, and metabolism were necessary for efficient warm-bloodedness. Amongst the key changes needed were the evolution of external hair to retain heat, and the development of a four-chambered heart to improve blood circulation. The history of the evolution of the early mammals reconstructed from the fossil record shows how these various components were improved individually and as a combination over a long period[7]. This progressively enhanced the ability of mammals to maintain a warm body temperature no matter what the external temperature.

So we have good reason to believe that much of the technology embodied in the adaptations of organisms will show the same potential for on-going improvement as many areas of our external technology. And the search mechanism of natural selection acting on genetic variation will progressively discover these potentials, producing progressive evolution in particular adaptations until the potential for improvement is finally exhausted.

Although the potential for progress in external technology and in the complex adaptations of organisms is similar, the actual rate of progress and its directness is very different. And these differences go a long way toward explaining why progress in genetic evolution is not as widely recognised as technological progress. Although both processes are fundamentally progressive, technological progress is a lot easier for us to recognise because it is more direct and it is faster, occurring during our lives.

The reason for these differences is that the genetic search mechanism is far inferior to the mechanisms that develop our technology. Genetic evolution is not very smart at exploiting the potentials for on-going improvement. Unlike us when we try to improve technology, it has no capacity to plan ahead, to use foresight, to visualise possible improvements, or imagine alternatives and try them out in its head before making them. Instead, without any idea of what might work and where it might lead, the genetic search mechanism blindly changes adaptations when new organisms are produced, and sees how the changes work in practice. There is nothing to stop the genetic search moving in the opposite direction to where the greatest improvements lie. A genetic change will be favoured by natural selection if it is better than what has come before, even though it might move away from greater potential improvement. And a change that is a step towards greater potential improvements will be reproduced only if it is itself an improvement.

Genetic evolution operates a bit like trying to improve a 1930's motorcar by making random changes to it in the dark, without any knowledge of how the car works or how it might be improved, and using parts you don't understand. The only feedback you would get about how you are going is to be told when a particular change is an improvement. We know from the history of cars since the 1930's that there are many on-going sequences of potential improvements that you could discover. However, if you set out to discover improvements using only blind trial-and-error, it would take you a very long time to make much progress and when you did, it would be very indirect.

Even where your search mechanism eventually exploited some of the potentials for improvement, the history of the changes that got you there would not look very progressive. There would be periods in which the search got stuck and no improvements were made, periods in which only minor enhancements were discovered and much better improvements were missed, and periods in which the changes that were made moved in the opposite direction to the potential for greatest progress. If you tried to decide whether such a process was fundamentally progressive by looking only at the history of changes, it would be very easy to get it wrong. It would be easy to get lost in the trees, and never see the wood.

This is the way that genetic evolution proceeds, even where the existence of potentials for on-going improvement makes it fundamentally progressive. The evolution of birds provides an example. It is evident that with the emergence and rise of land insects, large flying organisms that fed on the insects could be successful. Eventually this potential role was filled by birds. Despite the potential for success, the genetic mechanism was unable to evolve a group of insects to take up this role, probably because the insects were locked into having a hard external skeleton that is not as efficient for larger organisms as an internal skeleton. Although the insects were already there on land, it was not until many millions of years later that evolution eventually filled the role, and then only by an extraordinarily circuitous path. The ancestors of the birds came not from the land but from the water as amphibians.

The genetic evolutionary mechanism was completely unable to get itself unstuck by developing an insect with an internal skeleton. If it had done so, the role could have been filled quickly and directly by large flying insects. But in the absence of an asteroid or other catastrophe to undo enough of the evolution that had got it stuck, the genetic mechanism could not directly and immediately exploit the potential role.

So the opponents of a progressive view of evolution have found it very easy to go to the history of life on earth and point to absences of progress over long periods[8]. But they have failed to see that extensive periods without progress are an inevitable consequence of a blind trial-and-error genetic search mechanism. The survival of some groups of animals without significant improvement for millions or even billions of years is not conclusive evidence against progressive evolution. There may be potential improvements in those groups that genetic evolution has not yet been able to discover. Life may have to await the evolution of smarter evolutionary search mechanisms before evolution can explore some of these potentials.

Whether or not evolution is progressive, there will be species that do not progress for very long periods of time. To prove the case against evolutionary progress, it is not enough to point to organisms like bacteria that have flourished unchanged on this planet for more than 3,500 million years. Anti-progressionists must also show that there are no potentials for on-going improvement that the evolutionary search mechanisms have failed to exploit. They must show that there can be no alternatives to current bacteria which, if eventually produced by evolutionary search mechanisms, would prove far more successful than current bacteria in strictly evolutionary terms. They must show that, for what they do, bacteria are perfect, and there can be nothing better. And they must show that this will remain true whatever happens in the future evolution of life in the universe.

Gould and other anti-progressionists have not even attempted to meet this critical challenge. They have not explored the possibility that there are potentials for on-going improvement that evolutionary search mechanisms have failed to discover. They have not considered whether future evolutionary developments are likely to overtake bacteria in their current form.

A major task of this book is to take up this challenge. I will show that there are general potentials for on-going improvement that will drive future progressive evolution. And I will be showing that bacteria (and humans) that don't explore these potentials for progressive improvement will not participate successfully in the future evolution of life in the universe. They will progress or perish. We will progress or perish.

So far in this Chapter we have seen that there are likely to be potentials for on-going improvement in the technology embodied in the complex adaptations of organisms. Wherever the use of genetic trial-and-error is able to exploit these potentials, progressive evolution of the adaptations can be expected. But will this evolution produce a general advance in living processes? Will life as a whole progress in evolutionary terms? Or, as argued by Gould and his supporters, will this evolution produce only better adaptation to local conditions? Will progressive change occur only while there is room for improvement in adaptation to the specific and localised environmental problems met by each population of organisms?

We would expect to find general progress if all organisms had similar potentials for on-going improvement, no matter what the nature of their local environmental conditions. The general potentials would drive general advance. In what circumstances might we expect to find general potentials of this kind? Potentials would be general if a particular adaptive problem is encountered by all organisms. We would expect general progress in the development of the adaptive technology to deal with the problem. General potentials for improvement would also exist if there were complex adaptations that would improve all organisms, no matter what their local environment.

Where these general potentials exist, problems and opportunities faced locally by populations would also be problems and opportunities faced generally by all other populations of organisms. So if a population were to exploit some of these general potentials for improvement, it would not only improve its adaptation to its local environment, but also would improve in a general sense. It would improve in all environments. By achieving better adaptation to its local conditions, the population would participate in universal advance or progress.

But do these general opportunities and problems exist? It is certainly the case that some adaptive challenges and opportunities are very general, affecting many species. The need for some form of vision is widespread, as are the benefits of warm-bloodedness. And when we examine the history of life on earth, we find general advances in particular adaptations across many species where common adaptive problems or opportunities are found.

For example, eyes have evolved in many different organisms, as have the various features that were needed for warm-bloodedness in mammals. There are also many examples of general improvements that evolved in one or a small number of closely related species and then spread widely because they brought the species general evolutionary success. The general nature of these improvements enabled the original species to adaptively radiate into many other environments, often ousting species that had not developed the general improvements. The fossil record shows many spectacular adaptive radiations triggered by the discovery of complex general improvements. For example, major radiations followed the emergence of the first primitive fishes in the Devonian, the evolution of the first primitive reptiles in the Permian, and the rise of the first dinosaur-like reptiles in the Jurassic[9].

Of course, even where improvements provided general advantages in this way, many species were not replaced immediately by those with the improvements. In the case of some 'living fossils' they have still not yet been replaced. A species would not be ousted where it had valuable and specialised adaptations to local conditions that were not outweighed by the general improvements of the more progressive invaders.

This is another example of where the limitations of the genetic evolutionary mechanism mean that genetic evolution does not progress as quickly or as directly as technological evolution. When a general technological improvement is discovered, such as a lighter but stronger alloy, it can be readily combined with any other existing technology to produce improved solutions to particular problems. Technological evolution can easily combine the best with the best.

The genetic mechanism is unable to do this. It cannot directly combine adaptations discovered in different species. When a relatively general advance such as a better eye is discovered, there is no process that enables it to be immediately adopted by all those species that have inferior eyes. Again we find that although genetic evolution is as fundamentally progressive as technological evolution due to the existence of similar potentials for on-going improvement, it is far inferior at exploiting these potentials.

It is clear that there are adaptive challenges and opportunities that are not purely local. Some are general in the sense that they affect many species. But are there potentials for on-going improvement that affect all living processes, that are universal, and that will therefore drive the progressive evolution of life as a whole?

As I indicated in the first Chapter, I will be arguing that evolution progresses towards increasing cooperation amongst living things. To succeed with this argument I have to demonstrate that increased cooperation provides a general potential for on-going evolutionary improvement. To demonstrate this, I will have to establish a number of things. First, that increased cooperation amongst living processes has the potential to provide greater evolutionary success. Second, that this principle is general and the potential for greater evolutionary success applies to all living processes. Third, that the potential for improved evolutionary success is on-going, because evolution is unable to immediately exhaust the potential benefits of increased cooperation.

I will show that evolution exploits the benefits of cooperation amongst living entities through the formation of complex organisations of those entities. The organisations are structured so that cooperation is supported within the organisation. On this planet, evolution has produced cooperative organisations of molecular processes to form cells, cooperative organisations of cells to form multicellular organisms such as insects, frogs and ourselves, and cooperative organisations of humans to form human societies.

However, the formation of these structured organisations enables cooperation to be organised only between the living entities *within* the organisations. Evolution will not be able to exploit immediately the benefits of cooperation *between* the organisations. These benefits will not be exploited until the organisations themselves are organised into organisations, producing cooperative organisations of organisations. For example, the organisation of molecular processes into cells produced cooperation between molecular processes. But the benefits of cooperation between cells were not exploited until cells were organised into multicellular organisms. And cooperation between multicellular organisms was not exploited until the evolution of societies of organisms.

Continued repetitions of this process forms cooperative organisations of larger and larger scale, each containing the smaller-scale organisations that have evolved previously. As a result, human social systems include humans which include cells which include molecular processes. This evolution of organisations of larger and larger scale extends the scale over which living processes are organised cooperatively, but leaves unexhausted the potential for cooperation between organisations of the largest scale. The potential for further beneficial cooperation will not be finally exhausted until all living processes are permanently organised into a single entity that is of the largest possible scale. The potential for increases in the scale of cooperation in this universe will end only when the entire universe is subsumed in a single, unified cooperative organisation of living processes. It will end only when the matter, energy and living processes of the universe are managed into a super organism on the scale of the universe.

This evolutionary sequence has all the features of a process that is fundamentally progressive. The potential for almost indefinite expansion in the scale of cooperative organisation and the advantages this will bring provides a potential for evolutionary improvement that is on-going. And each step in the sequence of improvements builds on and goes beyond the improvements made in the previous steps.

The next five chapters are devoted to the development of these arguments in detail. We begin in Chapter 3 by exploring how cooperation can benefit living processes in evolutionary terms. We will see that by cooperating together, living processes improve their ability to meet whatever evolutionary challenges they face. Increased cooperation has a general potential to provide greater evolutionary success. And the wider the scale over which the cooperation is organised, the more successful the cooperators can be.