A Story About Us: Evolution and the Individual

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Introduction

This is a story, not a scientific document. It does not lay any claim to universal truth or accuracy, and the substance of the story has been gathered from a myriad of sources over many years. It is the product of an inquisitiveness and introspection we all share. It is part fact, part exploration, and part opinion, and like all stories, its value lies in how it captures your imagination and resonates with your own intellectual activities.

It is a story about us, and only us. We are the only actors in this story; there are no gods and no devils. Together with what we create - all the artefacts that make up the infrastructure in which we operate - we constitute what we call *society*, and so our story takes place on two scales: On the macro scale, it is the story of the evolution of society, on the micro scale it is the story of the individual. In addition, we shall sometimes draw analogies with a much smaller scale, that of atoms and molecules in the discipline of physics. And we will present a picture of the relationship between society and the individual as having some similarity to the relationship between thermodynamics and statistical mechanic. This picture is useful, and we shall return to that when we look at society as a system, in Chapter 2; where it fails is in that an individual human is not primarily a physical body identified by location, position, education, wealth, power, and the like; that is a largely static view. The primary view of a human is as an actor; its story is a sequence of actions from birth to death, and it is the multitude of these stories that make up the story of evolution of society.

Most stories have a theme or a moral; for example love, or sacrifice, or that the good will triumph, and so on. The theme of our story is survival - the survival of *form*. What we shall see as the story progresses is that evolution is a competition between two classes of processes; those that decrease order (or increase entropy) and those that increase order (or decrease entropy), and that the order created by the latter is displayed in distinct forms of varying complexity. At the lower end of the complexity scale we have atoms and simple molecules, at the upper end we have humans and societies. All of these forms are subject to the processes that decrease order, and the energy involved in these processes can be characterised by a single parameter, which we shall call *temperature*, and denote by T. For a given form, the effect of these destructive, or thermal, processes increases as the temperature rises in relation to a temperature that is characteristic of the form, T_c. For some forms, such as diamond, T_c is greater than a thousand degrees Celsius; for ice, T_c is zero degrees. In these two examples, the order is of a particularly simple, repetitive type called a crystal. The destruction takes place at T_c. For the forms we shall be interested in, such as organic molecules, the destructive effect is *probabilistic*. That is, there is a probability of the form being damaged by the destructive processes within a given time period, say, one hour, and it is this probability that is a function of the relation between T and T_c. Basically, it is a function of the difference between T and Tc, such that if $T >> T_c$, the probability is high; if $T << T_c$, the probability is low. However, the same processes that are used to damage the form can be used to repair the damage, if the required building materials and energy are available, and so the *existence* of the form is a battle between the two manifestations of the same basic process. It is this battle, which we experience as *life*, that is the theme of our story.

The motivation for this monograph was the difficulty experienced in finding a suitable forum for expressing and discussing some of the broader issues relating to the interaction between technology and society, or, more correctly, to the role of technology as a component or an aspect of society. Technology and its applications are inseparable parts of society, and the evolution of society is closely correlated with the development of technology. On thinking about this, I realised that presenting these issues in the format of a scientific paper was simply inappropriate. Firstly, the subject matter is too multidisciplinary to fit into any one of the increasingly narrow specialisations within science and their associated publications, where conformance to the established paradigm is a main criterion of acceptance. The current presentation draws on theories and results from systems engineering, physics, biology, philosophy, and sociology, but only to a level of detail relevant to providing an integrated view of evolution and our role in it; there is no intention of being rigorous or complete in any one of these disciplines. For those readers who would like to delve into the subject matter in more detail and to consult the original publications that provided, to a greater or lesser extent, inputs to this monograph, there is an extensive list of references at the end. Secondly, the view presented, and the choice of material included, are both personal, and readers might disagree with some or all of the ideas put forward, without any of us being able to prove we are right. And, finally, the intended readership is broad, including both practitioners in the disciplines mentioned and persons within the general public with an interest in the subject matter, and this dictates the language and style of presentation as well as the mode of publication.

Some of the material was already published by the author in academic journals and conference proceedings, but in each instance with a narrower focus and aimed at a more specialised readership. The purpose of this monograph is to tie this material together to show that evolution is a continuous story, and to make us aware that we are just the current actors in this same story.

Chapter 1 - Evolution

A simplified view

When we think of evolution, we might think of the evolution of the universe, from the Big Bang and then the creation of the stars and their planets, of which the Earth is just one of an extremely large number, but we are probably more likely to think about an evolution much closer to us: the evolution of life on Earth and how humans came into existence, the evolution connected with the name of Darwin. Consider, for a moment, a very simplified view of the evolution of life on Earth in terms of three overlapping phases. In the first phase, which started maybe 3.5 billion years ago, life developed from the simplest, single-cell forms to a myriad of increasingly complex and widely differing forms, with new species emerging and existing species becoming extinct in a relentless process of experimentation and survival in a continually changing environment. However, at any one time during this phase, there was a complex web of interactions between the species, in the form of food chains and various interactions between animals and plants, such as certain plants forming the habitats for certain animals, and so on. The result was the existence of a continuously evolving ecosystem, with mutual dependence and a lack of dominance between species; a sort of natural democracy.

This all changed with the emergence of the genus *homo* at the beginning of Phase Two, 5-8 million years ago. However the emergence of this one, very different genus took place, the evolution of the genus started to progress at an accelerating rate that soon set it apart from the other genera and liberated it from its role as just another component of the ecosystem. The development was one of increasing capability rather than a change of external form; capability that manifested itself in manual dexterity, speech, and cognitive processes, and which allowed humans to exploit the rest of the ecosystem as a resource and to isolate themselves to a large extent from the fluctuations in that ecosystem. This evolution then continued through the species *homo sapiens* to modern man, *homo sapiens sapiens,* which appeared a couple of hundred thousand years ago. This development of the genus *homo,* which was characterised by functionally important, but outwardly relatively minor physical changes, and by very significant mental changes, was also characterised by a rate of development more than an order of magnitude greater than that of the first phase.

The third phase, which started a couple of tens of thousands of years ago, is characterised by the formation of groups of mutually interacting and inter-dependent individuals, and it is now these groups, or *societies,* that are the individuals of the new "species", *homo conglomerasiens* (or something like that). Just like cells combined to form more complex organisms, humans combine to form entities that far surpass the individual in functionality and capability. And if we say that a characteristic time for change in the first phase might be something like ten million years, and in the second phase perhaps a couple of hundred thousand years, then the corresponding time in the third phase is, say, a thousand years and rapidly decreasing.

The main part of our story takes place in the third phase, but before focusing on that, it is important to see how evolution, as the development of increasingly complex forms, has been a continuous development, with each step in the development being contingent on its previous history. Going back to the concept of a critical temperature, T_c, we need to take cognisance of the fact that, in a general manner, T_c is a decreasing function of the complexity of the form. As the Earth cooled down and a crust formed on its surface, the temperature dropped below T_c for simple forms, such as molecules consisting of only a few atoms and so, as these molecules were created by the proximity of the constituent atoms and with the binding energy provided by ultraviolet radiation, they were able to exist. As the Earth's surface continued to cool, more complex molecules were able to exist, but at some stage T_c reached a value where thermal energy, in the form of the kinetic energy of the molecules, rather than ultraviolet radiation, was able to create new molecules, and to see how this had a major influence on the further development, we need to make a little detour in the form of a highly simplified model.

Consider two molecules of type A that are moving around as parts of a gas or a liquid. They have kinetic energies within the distribution that reflect the temperature of the substance, T (in a perfect gas, the mean kinetic energy of a molecule is equal to 1.5 kT, where k is Boltzmann's constant, and T is measured in degrees Kelvin). If they happen to get very close to each other, they experience a force, as illustrated in Fig. 1.1. In this Figure, the horizontal axis shows the distance between the centres of the two molecules, and the vertical axis shows the amount of energy required to attain a particular distance between them, with a positive value resulting from a repulsive force and a negative value resulting from an attractive force. As they approach each other, they experience a repulsive force, and if the kinetic energy is not large enough to overcome this force, they simply bounce off each other. But if the energy is large enough to overcome the repulsion, the two molecules experience an attractive force, and they become bound together to form a new, more complex molecule of type B.

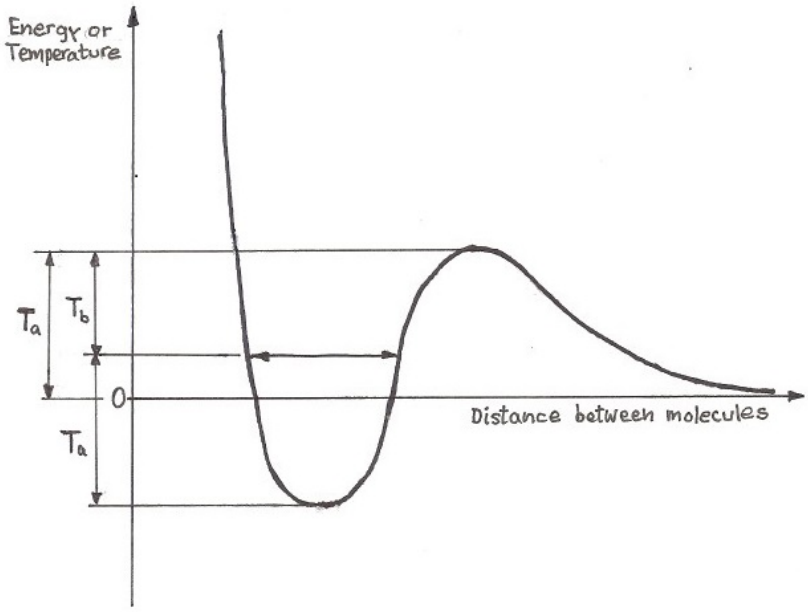

Figure 1.1 The energy, expressed in terms of temperature, involved in a collision between two molecules.

In addition to the kinetic energy, molecules also have internal energy, and in the case of our newly created molecule B it takes the form of the two A-components vibrating against each other, as indicated in Fig. 1.1. When molecules collide, energy can be transferred between these two forms of energy. It is like striking a bell with a hammer; energy in the movement of the hammer is transferred to vibrations in the bell. And, as also shown in Fig. 1.1, only an additional amount of energy is required in the next collision in order to break up the B molecule again. Let the temperature corresponding to the energy required to overcome the repulsive force be denoted by T_a, and let the temperature corresponding to the energy required to break the molecule apart be denoted by T_b. Then, the number of B molecules is determined by the product of the probability per unit time of a collision causing the formation of new B molecule, p_a, and the lifetime of a B molecule, which is roughly inversely proportional to the probability per unit time of a collision causing a complex molecule to break up, p_b. These two functions, and the resulting number of B molecules, are shown as functions of T in Fig. 1.2. The temperature range over which B molecules can exist is, of course, dependent on the value of T_b, which is again dependent on the strength of the binding force.

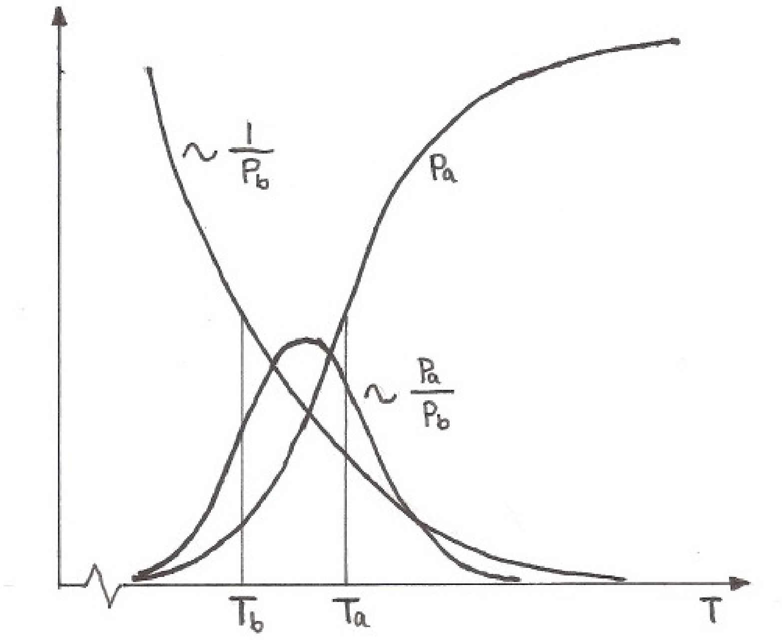

Figure 1.2 The number of complex molecules as a product of the rate of creation, or probability of creation per unit time, p_a, multiplied by the lifetime, which is proportional to the inverse of the probability of destruction, p_b. The vertical scale is arbitrary.

The description of the creation and destruction of the elements of a system in terms of a *system temperature* was explored in (Aslaksen 2007), where a simple model was defined as consisting of *n* identical *elements* that are able to establish interactions through *ports*; each element has m_0 ports. The interaction between two elements is initiated by what was called an *encounter*. The outcome of an encounter is one of two possibilities:

> *Formation* of a *link* between the two elements involved in the encounter, with probability *p*, and
>
> *dissolution* of a link attached to either of the elements involved in the encounter, with probability (1-*p*).

Each port has a *failure rate,* λ, and an element with one or more failed ports is replaced by a maintenance process that has a *rate of replacement,* μ. A mathematical model of this self-sustaining system demonstrates the existence of the life cycle phases of growth, survival, and decay, and, in particular, the numerical simulation shows that the size of the system in the survival phase, as a function of a quantity identified as the system temperature, has exactly the form shown in Fig. 1.2. This behaviour was foreshadowed in an earlier version of the model (Aslaksen 2004), where an engineering organisation was used as an example to demonstrate the importance of a balance between freedom (fluctuations leading to innovation, but also to organisational breakdown) and conformance (leading to efficiency).

As mutations generated more complex molecules, the temperature range in which they could exist tended to become narrower, and so, in order to be able to exist in an environment with fluctuating temperatures, a new feature was introduced into our story; that of *cooperation* between different types of molecules. A complex molecule would surround itself with simpler molecules that could form a barrier, or *wall*, within which the temperature could be maintained at a constant value, but through which the material required for growth and for fuelling the chemical processes that allowed the temperature to be maintained could pass. And so *cells* came into being, and the complex molecule at its centre, its *nucleus*, contained the information, in the form of its structure, that allowed the various molecules to cooperate in an efficient fashion, making a particular type of cell a survivor in the competition for resources against the many other variants thrown up by mutations. This formation of viable complex forms through the goal-oriented cooperation of simpler forms will be a recurring feature as our story unfolds, and the goal is always the same: survival.

The size of a cell, as measured e.g. by its diameter, d, is limited by the following consideration: The interactions with the environment in which it exists takes place through the cell wall, which has a surface area proportional to d^2. But the cell volume, and therefore the amount of material that has to be maintained through interactions with the environment, is proportional to d^3. So, as d increases, there comes a point where the surface area available to maintain a unit of the volume is no longer adequate. Furthermore, the processes taking part within a cell produce some unwanted molecules and waste products, so as a cell ages, it takes more effort to maintain it. For both of these reasons, a cell will remain at it efficient size for a certain time, but then both growth and maintenance is carried out by the cell dividing into two cells with identical nuclei. We can think of this as similar to what we do with our equipment, such as household goods, entertainment equipment, and cars: Once they get too old, it is no longer cost-effective to repair them, and they are discarded and replaced by a new copy.

The story of a relentless sequence of mutations and selection to create new, viable cells, as well as the cooperation among cells, both of the same and of different types, in order to provide new functionality that again proves itself successful in the struggle for survival, progresses in a seamless fashion through the development of more complex organs and organisms until we arrive at the third phase and the modern human. And the highly simplified model above demonstrates three important characteristics of the evolutionary process that will remain relevant while the nature of the evolution changes as our story progresses:

- The driver of creation is the same as the driver of destruction, from which it follows that
- there is no progress without simultaneous destruction or decay, and
- the process of evolution can only take place in a very limited range of the environment that drives it (in the above example, the temperature T).

The third phase

In the remainder of this monograph, our focus will be on the third phase; the phase in which the changes *within* humans, that is, in their physical characteristics, are negligible compared to the development of the relationships *between* humans. The third phase represents a complete change in the nature of evolution; it is so different that it is easy to overlook that it is a continuation of the same basic process – a struggle for survival. The subject of evolution has changed from the individuals of the species to entities formed by the interactions between the individuals, the pace of evolution has increased by orders of magnitude, and, above all, a great difference between the first two phases and the third one is not in the speed of evolution, but in what drives it. In the first two it is the Darwinian process based on genetic information and change of endosomatic organs; in the third phase change is by means of exosomatic instruments, the bearers of knowledge, with education and information exchange forming the core of the process. A similar view, although in a somewhat different context, was expounded some time ago by Sir Peter Medawar in a series of BBC lectures in 1959, and as a biologist and immunologist (and Nobel laureate) he used the evolution of *homo sapiens* and, in particular, of the human brain as the basis for his argument. For this purpose he divided the evolution of the brain into four stages: In the first stage, the brain was an organ that responded only to external stimuli by reactions that were already present in the brain. That is, a certain stimulus, which he called an *elective* stimulus, elected its corresponding reaction, but the brain would not react to stimuli that did not fall in this group. In the second stage, the brain began to be able to accept *instructive* stimuli; stimuli that contained information about how it should be processed. The development in these two stages depended entirely on a genetic heredity, whereas in the third stage, a non-genetic system of heredity evolved that allowed brains to do more than merely receive instructions; it made it possible for them to be handed on. The fourth stage is the systematic change in the nature of the instructions passed on from generation to generation; an evolution that has been progressing at an accelerating pace for the last couple of centuries. The conclusion Medawar draws from this argument is that social change is not governed by any laws other than laws which have at some time been the subject of human decisions or acts of mind, and the mechanism that supports this change process is the non-genetic heredity mediated through the transfer of information from one generation to the next.

There can no longer be any doubt about the fact that the development of humanity and our environment is driven by us. We are no longer the pawns in Nature's game of the survival of the fittest in a distribution created by random mutations; we run the game. Adam Smith's "invisible hand" is no longer invisible; it is our hand.

Sometime in the early days of Phase Three (or perhaps earlier), humans became aware that they were different from other living organisms. They no longer saw themselves as just another creature living in and as a part of Nature, but increasingly saw the rest of Nature as the *environment* in which their individual lives took place and which could, to some extent, be manipulated and exploited to their advantage and from which they could obtain some measure of independence. This recognition and understanding was a result of the shift in the balance of capabilities from the physical to the mental. And besides the increasing ability to develop technology and apply it to modify the conditions of existence, to which we shall return in the next section, it was accompanied by a shift in the balance between physical and mental activity. Existence had no longer just, or even mainly, a physical content, but also a mental content, and thoughts and mental images could take on a reality in a person's mind that was divorced from any physical reality. A consequence of this was that the fear of death, which all animals display, but which they presumably accept as the natural end to individual existence, could now be sublimated by a mental construct in which the individual continued to exist in some form in a mental realm, in contradiction to all physical evidence. The preoccupation with and embellishment of this construct in the form of beliefs, rituals, and religious systems have been central to the evolution in phase three and an inseparable part of our story of how we ended up where we are today.

In the book *The Death of Forever*, Darryl Reanney explores this issue from various points of view. He gives a very good account of the importance of death, whether consciously or unconsciously, in forming our character, and gives many examples of how our desire to transcend death has manifested itself in works ranging from scratches on a cave wall to the pyramids. It shows how all art includes a desire to overcome the transient nature of existence. Now, "transient" means "lasting only for a short time", and this brings us to a consideration of the nature of time. Reanney sees time as the greatest barrier that Nature has erected between the average structure of the human mind and reality, and death, as a marker in time, can only be transcended by a pure, universal consciousness that is freed of time. He believes that, to the highly evolved mind, which has filtered out ego noise, reality appears as a timeless continuum. Without entering into the issue of a pure consciousness, Reanney's treatment of time and its relation to the cycle of human life, both the short-term circadian cycles and the long-term one ending in death, is thought-provoking, but then, in the end it seems to miss what to me would be the proper conclusion: Rather than reality being a timeless continuum; that is, something existing unchanged *in* time, it is time that has no reality. Time is a concept we have invented as an arbitrary measure of change; the reality is change. In a universe where nothing changes, not a single elementary particle moves, there could be no concept of time. Of course, there would be no humans, either. The concept of time depends on the ability to perceive change, which is again contingent on memory. So, in a universe without organisms with memory there could not be any concept of time, either. We are so conditioned to thinking and speaking of time as an actual physical parameter; for example, we talk of something being a function of time. And when we say something happened later, we think in terms of elapsed time, rather than after something else had changed.

This is relevant to our story because, as we saw earlier, the time-frames of the three phases are very different. In particular, we shall discuss how the rate of change has been, and is, accelerating in Phase Three. In the last century, the life span of humans has not increased dramatically when measured in normal time, but if we would use the rate of change of our environment as our “time” scale, we would say that we are now living very much longer than a century ago.

The third phase is characterised by the interactions that take place between humans, and by the entities that are created as a result of these interactions. At some level of size and/or complexity we call the entities *societies*, and they are the focus of the next chapter. But before we go on to investigating societies, we should look in some detail at what is perhaps the hallmark of phase three, and that is technology. Technology is an expression of both our manual and intellectual abilities, but has at the same time provided the momentum for the development and exploitation of those abilities. And it is this positive feed-back that has resulted in the accelerating pace of evolution in phase three. Without a good understanding of what technology is and of the interaction between it and society, it is not possible to comprehend how society got to where it is today and to see what our realistic options for the future are.

Technology and its influence on evolution

The use and meaning of the word "technology" are broad and highly context dependent, as can be seen by looking up the word in Wikipedia. The word relates to the field of human activity that may be described as the modification of elements of the natural surroundings in order to meet a need; what we might call a *purposeful* modification. It started when humans developed the mental ability to recognise the possibility of such a modification and the physical dexterity to realise it, and the purpose included giving visual pleasure or increasing one's self esteem (painting, ornaments, sculptures), worshipping a deity (monuments, temples), providing shelter (dwellings), increasing mobility (roads, bridges, boats), providing food (traps, weapons, agriculture), preparing, serving, and storing food (bowls, pots, plates), and so on. This is roughly what the ancient Greeks identified as *techné*, any creative manual activity and the products that arose from it, and in this sense we can say that the start of technology is identical to the start of our Phase Three.

Philosophers and most sociologists have a broad concept of technology, and would accept such a definition as "artefacts and their development, production and use". Philosophers have produced a substantial body of work under the heading of "Philosophy of Technology". It is concerned with ethical aspects of technology, with the nature of technological knowledge, and with fundamental issues regarding the impact of technology on the human condition. Sociologists have likewise taken an increasing interest in technology, studying technology as a social activity and how social issues influence the development and application of technology. However, in both of these disciplines there has been a tendency to confuse technology with science, and engineers with scientists; many publications on the philosophy of technology make no mention of engineering at all, and such concepts as "technoscientist" and "technologist" tend to confuse the issue even more. One reason for this is probably that the philosophy of science was already well established and provided the point of departure for work on technology. Yhis is reflected in the implicit or explicit view of most philosophers and sociologists that technology is driven by scientists, rather than engineers, as evidenced by the common reference to "Science and Technology". Science provides the basis for developing new technology, but the main creators of new technology, as well as the creators of new applications of technology, are engineers. And engineering is very different to science, both in its approach and in its relationship to society. A lack of appreciation of this difference, and of the role of engineers in general, has often made publications on the relationship between technology and society seem somewhat artificial. Basically, whereas science is about discovering the truth of our understanding of Nature, engineering is about using that understanding for beneficial purposes. And whereas the paradigm within a domain of science can change relatively rapidly, caused by a single revolutionary new theory, such as the heliocentric view of the solar system, Newton's laws, Darwin's theory of evolution, relativity, and quantum mechanics, changes within engineering are more gradual. In particular, it is not that existing engineering knowledge and works are found to be incorrect and need to be discarded; it is that new knowledge and works are added and then, over time, replace the old for reasons of greater cost-effectiveness.

For our purpose of integrating technology into our story of evolution, we adopt a more specific and sharply defined definition of technology: Technology consists of a resource base (construction elements, tools, etc.) and a knowledge base (text books, publications, standards, heuristics, etc.), and engineering is the process of developing and applying this technology in order to meet needs expressed by groups or all of society. The construction elements range from cement and reinforcing steel rods to integrated circuits, and it is the existence of this vast collection of standardised elements, listed in numerous catalogues and defined in various documents, that underpin the efficiency of modern engineering. For example, if we had to design a bolt or a drill bit every time we needed one, we would get nowhere. To see how the development of technology fits into Phase Three, Table 1.1 sets out a more detailed time frame and notes some of the most important characteristics of this development.

Period	Approximate duration	Development of technology
Ancient	Until 500 BC	Knowledge transmitted verbally and by example. Resources limited to timber and stone, with some metals and simple hand tools
Classical	500 BC to 400 AD	Written records of designs and of scientific input appear. Resources include bricks and concrete, iron/steel becomes more available
Medieval	400 to 1400	Slow increase in knowledge base; improvement of existing designs. Increase in mining technology.
Renaissance	1400 to 1650	Expansion of knowledge base due to upsurge in science and printing.
Enlightenment	1650 to 1750	Further interaction with science, improvement in fabrication methods (precision, standardisation).
Industrial Revolution	1750 to 1850	Rapid increase in all aspects of technology. Formalisation of the technology through education (textbooks).
Production	1850 to 1980	Very great expansion of the technology; in particular, of the resource base in the form of standard construction elements.
Information	1980 and ongoing	An increasing proportion of technology is becoming related to software.

Table 1.1 A condensed view of the development of technology.

Applications of technology have become so embedded in society and of such importance in our daily lives that we can say that technology is now a defining component of our culture, together with such other components as art, religion, and the rule of law. The evolution of society is strongly influenced by the development of technology, and as we have seen that we are now in charge of this evolution, our understanding of technology, the manner in which we control the development of technology, and how we decide to apply technology, become essential factors in assessing how evolution will progress from here on.

It is not difficult to find examples of how, in the past, technology and its application had a major influence on the evolution of society. For example, the ability to form large-scale communities, as in cities, and thereby enabling the cooperation we mentioned earlier, depended on the development of civil and structural technology: water supply (dams, aqueducts, wells), sewerage and drainage (pipes, canals, tunnels), brickwork, etc. Or, the ability to separate workplace from place of residence through mechanised transport (railway, ferry, tram, bus, and car). And in the present day there are technologies that have, or will have, significant impact on the further evolution of society, such as genetics, nuclear technology, and renewable energy technology. These obvious examples can also make us overlook some less obvious, but, in the long run, not less significant influences of technology, and we shall return to that in the next chapter. However, what we need to realise a this point in our story is that technology is so closely interwoven with evolution in Phase Three that any consideration of the manifestations of evolution, or of what drives evolution, or of the interactions between individuals as the elements of evolution, must take account of technology, and so we shall return to the characterisation and influence of technology again and again as the story progresses.

The direction of evolution

We have spoken of evolution and of particular changes within this process, but how would we measure evolution and how a particular change contributes to evolution? Environmentalists might think of changes to the environment, such as deforestation, loss of biodiversity, and the like, but as we are considering Phase Three, we know that these changes are secondary changes; they are the result of the primary changes, which are the changes to society. And there is no use looking for changes to the physical characteristics of humans, as the basic elements of society, as these have been minimal. The evolution of society can be measured in terms of many different parameters, depending on what one intends to achieve by the measurement. One measure might be the size of society, measured by national or total world population; another measure might be the Gross National or World Product; a further one could be the number of books published each year, or the level of education world-wide, and so on. And, as we saw in the previous section, the extent of technology could in principle be an obvious measure, even though the definition of this measure is difficult due to the fuzzy meaning of “technology” in daily language. It could also be a combination of measures, but in any case, in addition to the measure(s), we need to have a concept of what we believe is a good direction of evolution, as expressed in terms of our chosen parameters.

The operative word here is “direction”. Consider, as a simple, but concrete example, the movement of a car. As we have a measure of distance – the metre – we can measure how far it moved in a given time, and, by dividing distance by time, we can determine the speed of the movement. We can also measure the direction in which it has moved, by comparing with a preferred direction, such as the direction of the road or a compass direction, and the measure is in degrees. For none of these measurements is it necessary to know where the journey will eventually end, or if it even has an end. It is a bit like Forrest Gump; the essence is in the journey, not in the goal. If we look back at Phase Three, evolution is very evident; it has taken us from the cave to where we are today. But is there a direction, or is it just a random process with no discernible direction? Looking at human history over the last ten thousand years or so, there can be little doubt that the “richness” of life, as measured by the diversity of our concepts and experiences, both on the average and in total, has increased exponentially in historic times, despite many setbacks in the form of wars and ideological subjugation. In most of the world, the opportunities for self-fulfilment available to the average person through material well-being and the associated free (or non-working) time, education, and an intellectually stimulating environment have led to societies that are again promoting those same factors, while attending to the various issues, moral and otherwise, accompanying that development. While it may appear that “the good life” has become synonymous with material success; it must not be overlooked that the access to and participation in all forms of art and political, scientific, and religious discourse, as well as a greater understanding of our environment through education and widespread dissemination of information have greatly increased the non-material content of the average person’s life. And while this does not tell us where we will ultimately end up, or whether this is even a question we can expect to get an answer to, we can determine the direction in which we have been heading; a sort of local or differential determination of direction. One question would then be: Is this a “good” direction? Most attempts to provide an answer to this question presuppose that it is to be sought in something external to us; by recourse to a divine or supernatural authority. But if we understand that we are now the masters of evolution, the answer must be sought in an understanding of the characteristics of that mastery. And the unfolding of our story will be similar to the approach applied in order to understand any organism, such as an animal. First we observe its external characteristics: its size, weight, mobility, lifespan, feeding and mating habits, number of offspring, and numerous other observables. We are able to describe its life cycle, how it develops from birth to death, and we get to understand its behaviour, how it will react in certain situation. But then we want to know what makes this animal display these external characteristics and function as it does. We start looking inside, dissecting the body into smaller and smaller parts, determining their characteristics and how they interact, and arriving perhaps at an understanding of how different types of cells work together to form organs and the whole animal. Reflecting this onto the evolution of humanity in Phase Three, the animal is represented by society, and so the next chapter is concerned with gaining an understanding of the life cycle and behaviour of societies. Chapter 3 then looks inside societies, where the cells are represented by individual human beings. Just as the basic process of life is contained in cells, the basic force driving the existence and evolution of societies is to be found in the individual. If we can gain some insight into the nature of that force, we might be able to see what the direction of evolution is. Hopefully the telling of this story will contribute to that.

Chapter 2 - Society

Definition of the concept

The word "society" is used to describe a wide range of associations between the people in an identifiable group. Some of them very loose and playing only a minor part in the lives of the people involved, others describing a strong interaction that constitute a significant aspect of the existence of the members. Among the former are such societies as most professional societies, special interest or hobby societies, and sporting associations, among the latter are religious societies, such as the Society of Jesus or the Society of Friends. All of these are characterised by the fact that the members belong because they want to belong; membership is an expression of the individual's will. The societies we are interested in, which are generally nations or, in some cases, the world's population as a single society, are of a different type. In these societies, people are members by virtue of being resident within the geographical area that defines the society; the extent to which an individual participates in the activities of the society varies considerably, and in some cases there is no definite requirement to participate in any of them at all. With a few explicit exceptions, in this monograph we shall take "society" to be identified either by "nation" or by "world". Which one of these is applicable will be easily understood from the context.

However, while a society is identified by a nation (or the world), describing a society is a different matter. It is similar to identifying a person by its name; it says nothing about the nature or character of the person. Like a person, a society is a very complex entity, and there is almost no limit to the level of detail and the number of parameters that can enter into a description of a society. To get a handle on this complexity and make a start on understanding what a society is, we can use a well-known approach, which consists of viewing a complex entity as a *system*, and then employ a number of existing tools or methodologies for analysing systems. This *system methodology* was originally developed as an aid in creating complex technological entities, such as telephone networks and missile defence systems, but it has since been generalised to apply to both the creation and analysis of any complex entity, and can simply be viewed as a means of handling complexity of any sort.

Society as a system

The word "system" is used in all areas of human activity and at all levels. While its meaning can vary widely, it is usually understood in a general, if often quite imprecise manner, from the context in which it is used. For example, if one speaks of "the public health system", nobody will ask what that means, even though most people have only a vague idea of what it all involves. One can say that for something to be characterised as a system, it would have to consist of parts that are related in some way so as to allow us to perceive it as a whole; i.e. with its own properties that can be defined without reference to its parts. That is, a system is a mode of description; we can decide to describe something as consisting of interacting parts or we can describe it as a single part; nothing *is* a system. More formally, a system can be defined as consisting of three sets:

- a set of *elements*;
- a set of *internal interactions* between the elements, such that no subset of the set of elements is disjoint from its complement; and
- a set of *external interactions* between one or more elements and the external world; i.e. interactions that can be observed from outside the system

Implicit in this definition is the existence of a *boundary* between the system and the external world; an element is either a member of the defining set of elements, and so within the boundary, or not. The extent of the external world is defined in each case by the external interactions; of all that is outside the boundary only those parts that interact with the set of elements is taken into consideration. As everything in the universe interacts with everything else, this immediately raises two questions: how do we decide on a set of elements and, having done that, how do we decide which interactions to include in the external interactions, thereby neglecting the rest by implication? The answer to the first question is simple: it is decided by definition. We are free to decide on any set of elements, it just depends on what we want to describe and the purpose of the description. For a given purpose, a suitable choice of elements is a matter of judgement and experience (it is what makes systems engineering an art). In general terms, it means that the effect of the elements on the external world, through the external interactions, is much less than the effects of the internal interactions on the elements, so that one can sensibly speak of the behaviour of the system as something particular to the system, without considering any response of the external world.

The answer to the second question is to be found in the realisation that, even though having chosen the extent of the system by defining the boundary so that the effect of the system on its environment is negligible, the behaviour of the system is generally a very complex function of that environment. The approach is then to try to look at certain *aspects* of that behaviour in isolation; that is, how the system behaves if, say, only one of the parameters describing the environment changes. But that behaviour may well depend somewhat on the current values of many of the other parameters describing the environment. It then becomes a question of the accuracy or significance of the description of the aspect of behaviour as to which parameters are taken into consideration. For example, as a practising consulting engineer, I also own a share portfolio, and the aspect of my behaviour under consideration is: how do I react to a change in the economy? Do I take adaptive action, or do I simply ignore the change and ride it out? That could depend on several variables, such a s what my friends do, what I read or see in the media, on how anxious or relaxed I am in my life otherwise, and so on, in principle making my behaviour very complex. But it turns out that there is one overwhelmingly important interaction with my environment, and that is my current consulting workload. If I am busy, I do nothing; if I have spare time, I do some research and shift my portfolio to respond to the change. Neglecting all other influences, this is still a reasonably accurate description of this aspect of my behaviour. So, while the answers to both questions involve a choice about which interactions are significant, the two differ in an essential feature: The first question involves the *dynamics* of the interactions with the environment, the second does not. We shall encounter this difference again at the end of this section.

Let us now see what this means if we want to describe a society as a system. One approach is a historical, bottom-up development. The simplest society would be a single (extended) family, living largely in isolation, as might have been the case of a family of cave dwellers some twenty thousand years ago. The system consisted only of the people in that family, they constituted the set of elements; everything else, including the cave, was the external world. The animals they hunted and the berries, fruits, and the like they gathered, which were part of the external interactions, had no impact on what we would call the environment in which they lived and in which the system existed. As families became settled through starting agriculture and animal husbandry (and also forming themselves into larger groups), they did have a significant influence on the immediate part of what was previously the external world, and their dwellings, stock and field enclosures, and other constructions, such as dams or bridges, would now have to be counted as part of the society and therefore as elements of the description of that society as a system. The part of what had previously been the external world, which was still largely unaffected by the enlarged system, was outside the system boundary and formed the environment in which the enlarged system existed. The external interactions in the direction from the environment to the system were significant (rain, draught, floods, landslides, changes to river beds, etc.), but there was little impact of the system on the environment.

As populations grew and societal structures became larger and more complex and, above all, under the influence of technology, the boundary between society and the part of the rest of the world relatively unaffected by society moved further and further outwards, society is today, as a system, most appropriately taken to be the whole of Earth, including its atmosphere. There is no unaffected "environment" of this system left; except for solar radiation and our embryonic interactions with space, which in the current context and for the time being we can safely neglect, our society is an isolated system. This is what The Club of Rome identified as Spaceship Earth. In terms of the three phases of evolution and the development of species introduced above, we see that the third phase has advanced to the point where there is only one "species" - our society - and the further development is not one of speciation, or cladogenesis, but one of evolution of that one society; that is, a case of social anagenesis.

This bottom-up approach is the classical approach to design, starting with the smallest, most detailed building blocks (in engineering, these are called construction elements or components), combining them into larger elements, then combining these into subsystems, and, finally, combining the subsystems to end up with a system that meets the requirements or, in our case, displays the observed behaviour. However, even after a couple of levels of combinations the number of parameters and the possible interactions have become so large that it becomes very difficult to ensure that one is heading in the right direction, and so the system methodology takes the opposite approach. It starts from the top, in our case society as an entity characterised by its purpose, and then proceeds in a top-down, step-wise fashion to *partition* the elements on one level into smaller, interacting elements on the next level down, but such that the character of the entity is preserved at each level. The system view of the entity emerges as a result of this process. This may at first seem somewhat abstract, but hopefully applying this methodology to the entity of interest to us, a society, will make it clearer.

A complete, detailed description of society would be a very complex system. Not only does it contain innumerable elements and interactions, but these also change over time; it is a dynamic system. It is not possible to consider a whole society at this level of detail, so, as we already used an analogy with thermodynamics above, we might take this a step further. A volume of gas is a very large system, but instead of considering it at a microscopic level, i.e. the level of individual molecules, we usually consider it at a macroscopic level, i.e. as an entity characterised by a few macroscopic parameters, viz. pressure, temperature, and volume. To find similar "macroscopic" parameters for society, it is necessary to first recognise a significant difference between gas molecules and the elements of society: the latter are active, whereas molecules are passive. The activities make up the processes that describe what the society does, what takes place within the society. Society is "alive", and these processes are the equivalent of the processes taking place within a living organism.

The first thing we must do is to decide what aspects of society we want to investigate and understand by describing it as a system. Do we want to understand what elements society is composed of? Do we want to understand what functions society performs? Do we want to investigate the stability or dynamics of society? Well, actually all of these and, above all, we want to understand how society is a result of interactions between individuals, and so we will need to develop a set of system descriptions of society, each description called a *view*. In accordance with our definition of a system, each view consists of a set of elements and interactions between them. As there are numerous ways of choosing both the elements and their interactions, there are a great number of possible views. Some of these are more commonly used than others, and a set of views that are used to describe society in a particular context is called a *framework*, because these views, being concerned with the same object, are closely related and so form a sort of system of their own, which is the framework.

For example, the elements of society as a system can be governments, government bodies, companies, organisations, tribes, families, and so on, and, as the elements of which these are constituted, individual human beings, but also all the various elements of our infrastructure, including technology. This is a particular type of view of society as a system, what might be called a physical view or, in model based engineering, a block view. But there are many possible views of this type, at different levels of detail, depending on the purpose of the description. One possibility would be to describe society as a system of individuals, but group the interactions between them into two groups according to whether they increase or decrease their common purposes, which is what binds them together as a society, and to characterise the relative strength of these two groups by a single parameter, the "temperature" of society. Alternatively, this temperature could be thought of as characterising the balance between the benefits of being a member of society and conforming to the rules of this society, and the restrictions and loss of personal freedom these rules represent. This parameter determines the stability of the society, and if the interactions that decrease the binding become dominant, the society might fall apart, as happens in revolutions, such as, for example, the French Revolution and the Russian Revolution. This is the equivalent of a phase transition in thermodynamics, the "temperature" of society reaches the "melting point", and the two examples demonstrate what we realised in Chapter 1: the range of environments in which a species (including a society) can exist is relatively narrow, and the stability of existence is a delicate balance.

As an aside, in Australia the current debate about education seems to miss the point that one of the important benefits of a common public education system is that it provides perhaps the strongest of the binding interactions, and the debate about immigrants and refugees seem to miss the point that the influx into a society has both a positive (invigorating) and a negative (perturbing) effect, and that optimising the balance between the two requires active, real-time management.

At the other end of the scale of block views one might describe society as consisting of only two elements, say, for a certain purpose within the field of economics, the public domain and the private domain. We can then speak of public and private finances, of public and private contributions to the GDP, of the interaction between the two via the taxation system, and so on. This example also demonstrates a feature that must be kept in mind: a given individual can be in both the public and the private domain, so that when one talks of individuals as interacting elements, it is the individual in particular roles that interact. The multiple roles of the individual is an important feature of life in such a description, and this applies also to the following somewhat different, but closely related view, in which society is partitioned into two entities, the state and the citizens. The relationship between the two can best be described as a love-hate relationship, and the ratio of hate to love is a significant contributor to the "society temperature" we introduced above. On the one hand, the state is one of our finest creations; it is to society what the nucleus is to a cell, and contains much of what we identified as the exosomatic genetic material transmitted from one generation to the next in the evolution of society. It provides and maintains the infrastructure we rely on every day, in health, education, transport, power, law enforcement, and so on. On the other hand, the state is viewed as "the enemy", and we go to great lengths to avoid contributing to it (e.g. through aggressive tax minimisation schemes) and to conforming to its structure and rules (e.g. by setting up competing organisations and engaging in costly legal wrangles). We might view this as a healthy process of checks and balances, but it is more likely to be a disturbing disjunction between the society's view of the state, as in government, and of the country or nation, as in the place where we live and which we celebrate through such symbols as the national anthem, the flag, national sports champions and teams, the War Memorial, and so on. And there is a corresponding disjunction apparent in government, in that politicians increasingly see politics as a business with re-election as its return on investment, rather than a service to the people, with quality as its measure. This whole issue is closely coupled with the role of technology in society and its evolution, and will therefore surface several times in this monograph.

Returning to our investigation, the context is the evolution of society and the role of individuals, and so we shall develop a framework consisting of views that are particularly useful in this context. As a first view, let us look at in what *activities* people spend their time, and to that end we might decide to consider all activities taking place in society to be grouped into five groups, as shown in Fig. 2.1. The interaction between these groups is that the sum of the time spent in each one of them must equal the total available time.

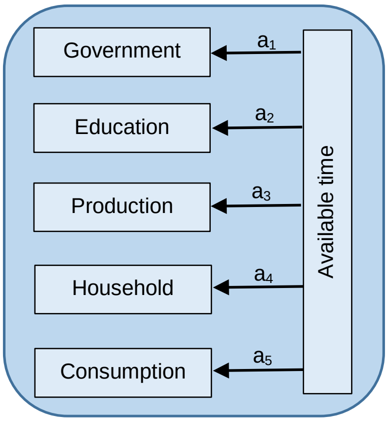

Figure 2.1 The *activity view* of society; with the five activity groups in which the members of society (i.e. the population) spend their time. The definitions of the groups are as follows:

Government:	Legislative, executive, legal and law enforcement institutions, defence, customs, taxation, and other administrative services.
Education:	Teaching and studying at all levels.
Production:	Provision of goods and services, incl. research, development, manufacturing, sales, marketing, construction, operation, and maintenance, and incl. government owned operations (transportation, health, water, power, etc.).
Household:	All the household work that could be performed by paid staff.
Consumption:	All other activities.

The five parameters, a_i, are the proportions of available time spent in each of the five groups over the lifetime of the average person.

To illustrate the meaning of Fig. 2.1 by an example, let us look at a generalised, and somewhat hypothetical example of a developed nation, but one which is patterned on a real nation, Sweden, for which good statistical data is available. There, the lifetime of an average person is about 80 years. However, it takes some time after birth before the person accounts for activities and expenditure in its own right, so let us simply discount the first 5 years from this activity view. Of the remaining 75 years, a certain amount is spent sleeping; say, on the average 8 hours per day, so that the time available for spending on the five activities identified in Fig. 2.1 is 438,000 hours.

Let the working portion of the lifetime be 45 years (from 20 to 65 years of age). From the Swedish data, the time spent working per person in this age range per week is 26 hours (to which we add 6 hours for commuting) or, over the lifetime, 74,880 hours (this excludes household work), and this is distributed over the three activity groups labelled Government, Education, and Production in Fig. 2.1.

Each person might spend an average of 30 hours per week, or 1,200 hours per year, over 15 years (from age 5 to age 20) on education, equating to 18,000 hours. If 1 in 13 is engaged in teaching, this equates to another 4,680 hours on education, or a total of 22,680 hours, so a_2 = 22,680/438,000 = 0.0518. And if 1 in 5 is engaged in government activities (excluding education), a_1 = 12,168/438,000 = 0.0278. As a result, it follows that the time spent on production is 74,880 – 4,680 – 12,168 = 58,032 hours, and a_3 = 0.1325. In this simple example we make no gender distinction, so it might be reasonable to say that each person spends 2 hours per day between the ages of 25 and 75 on household work, or a total of 36,500 hours, so a_4 = 0.0841. We then have that the time remaining for consumption equals 438,000 – 74,880 – 18,000 – 36,500 = 308,620 hours, so a_5 = 0.7046.

If we now want to consider these activities in the context of evolution, we need to take account of the decrease in life time going back in time, at least back to when some data is available, which for Sweden is about 1750. The life expectancy, or expected age at death, for persons at age 5 is shown in Fig. 2.2

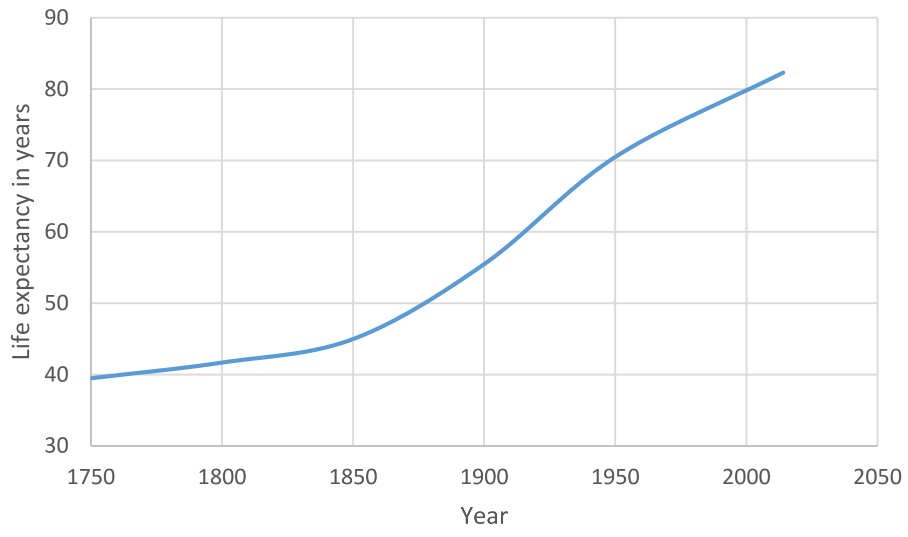

Figure 2.2 Expected age at death for persons at age 5. This is an approximation due to the uncertainty regarding the extent of infant (i.e. < 5 years of age) death rates in the early years.

If we now look at the year 1750, the hours available to the average person (e.g. per capita) for the five activities in Fig. 2.1 were 204,400. The working portion of the lifetime would have been approximately 27 years (from 13 to 40 years of age), and with a six day working week at something like 10 hours per day, the time spent working over the lifetime was 4,680 hours. Each person might have spent an average of 15 hours per week for 6 years, equating to 4,320 hours, and teaching would have accounted for about 800 hours (i.e. about same ratio of teachers/pupils as in 2000). It is difficult to determine the amount of time spent on household chores, as these were very much integrated into the work (e.g. as in agrarian production for own consumption), but in the absence of anything more definite, we might assume it to have remained basically constant. That is, the gain effected by various household equipment was absorbed by larger houses and higher standards. So, 2 hours per day between ages 13 and 40, or 19,656 hours. As a result, the time remaining for consumption was about 89,800 hours.

From the above (very rough) calculations related to our activity view we only need to keep two results in mind as we progress: Over the period of 250 years, the time available for consumption, i.e. discretionary or “free” time increased by a factor of more than 3, and the level of education increased by a factor of more than 4.

Another view that will be useful in considering the influence of technology on the evolution of society is what we might call the *process view*. There are a vast number of processes taking place within society, and following our system approach we start, at level 0, by representing this complex collection as a single entity, hiding all the complexity. There are many ways of partitioning this entity, and as the first level we partition the processes into two groups: institution processes and people processes, as illustrated in Fig. 2.3. The first are processes that produce goods and services, as well as remuneration in various forms; the second are processes directly related to people, such as work and consumption. This is not a simple partitioning, as the example of a subsistence level farmer demonstrates, but even here it is possible to think of the farm as the institution which produces products, and the farmer receiving remuneration in the form of produce and also consuming these. Obviously, this very high level model cannot account for anything but a stationary process, where the value of the goods and services must equal the remuneration.

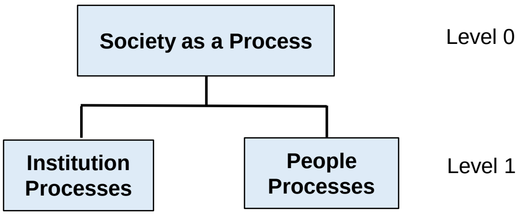

Figure 2.3 The first level of partitioning society as a process, into institution and people processes.

In the next level of partitioning, we can represent each group by two processes, as shown in Fig. 2.4. If we for a moment disregard the group of Capital processes, then the Figure represents the economy in a very early and primitive society, a society in which the raw materials used for production, such as land, timber, minerals, etc. were *free* to be exploited; there was no *ownership* of the resources. The closed loop (b,c) represents a fundamental aspect of any society, starting with a single family. The husband would hunt, and the wife would collect roots and berries, each one providing for the other. If the society expanded to encompass two families, and one was skilled in making stone tools, then the other family had to be skilled in something else, for example, making pottery, and so they could exchange products. This mutual economic dependence is a basic characteristic of any society, and one of the major "binding forces" in our thermodynamic analogy, but it tends to become obscured by the complexity of modern society.

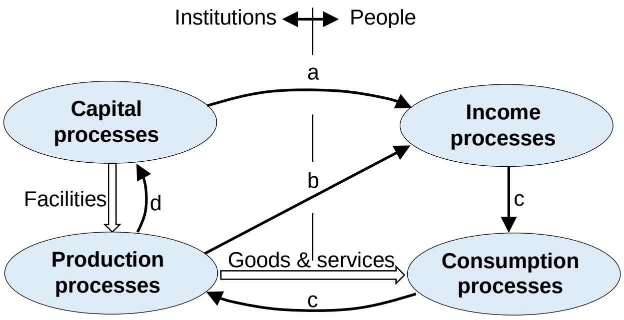

Figure 2.4 The second level breakdown of society into four groups of steady-state processes, two institution processes and two people processes. The four arrows labelled a, b, c, and d, are monetary flows.

The major change in the development of society came with the introduction of *ownership*. This ownership has two very distinct components. One is the ownership of something the owner has created, such as a dwelling or a tool; it is created as part of the Production processes, and is reflected in our model by d being greater than $c - b$. The other is the ownership of resources; that is, ownership of something the owner has had no part in creating, and the combined value of these assets is what we call *capital*. This introduces the group of Capital processes in Fig. 2.4; they are the processes that convert capital, C, as the measure of ownership, into production facilities. and allow the owners to extract an income stream, a. The production process then uses people to convert the facilities, the payment for which is included in d, into goods and services, for which the consumption process returns a revenue stream, c. It is very important to recognise that, in this picture, the material input to the production processes (raw materials, construction elements, etc.) play no part; the inputs of one operation are just the outputs of another one. The revenue represents the value *added* by the application of capital and labour. For their role in the production process (which includes maintenance), the people receive an income stream, b; this is part of the income process. At any one point in time there is the requirement that $c = a + b$, which is now the expression of the mutual economic dependence mentioned above, and the only interesting feature of this “steady-state” model is the fraction a/c. In a technically primitive society, this ratio will be very small, as a is almost zero, just the value of some simple tools and structures. In a technically advanced society, the ratio will be much greater, as a represents the return on a very sophisticated infrastructure and, most importantly, the in-ground value of the raw materials (which in this generalised sense includes land), which in this society are no longer freely available, but tied to owners. In the limit, one could conceive of a society where the production process is fully automated and labour has been eliminated and replaced by robots, and ownership is the only parameter defining the individual lifestyle (via the consumption process). A capitalist utopia, but a human nightmare. Society is turned into a giant game of Monopoly!

What we can discern already at this high level of description is the significant influence technology has on the development of society. The obvious influences are labour-saving devices, increased mobility through mechanised transport, etc., but there is a more subtle, or at least more difficult to describe and quantify, manner in which technology influences our world view and the relationships that define the structure of society. One such influence is on our attitude to Nature. Instead of valuing Nature as the environment in which our existence unfolds, the power of technology leads us to view it as something to be exploited, as a commodity. This was perhaps first expressed explicitly by Heidegger in his work *The Question Concerning Technology*, but has since been addressed from various points of view by many authors, including Ellul and Habermas. In short, technology is entering into the definition of what it is to be human, and we are evolving into a biotechnological species.

In this picture, the Income and Consumption processes are instantaneous, or zero-sum, as is reflected by both input and output of the Consumption processes being equal to c, and also by the equation $a + b = c$. The Production processes are, of course, neither instantaneous nor zero-sum; it takes time to develop new products and to construct new production facilities, and, as discussed above, $d > c - b$. But if we include these activities in the Production processes, we can simplify the dynamics by having only one “reservoir” of value: the capital C, which is converted into the facilities required by the Production processes, and for which they pay at the rate d, consisting of depreciation, a return on investment, and the *profit* of the Production processes.. For example, in the case of a coal mine, it is convenient to think of the life of the mine as consisting of two phases. In the first phase, capital is invested to buy the mining lease and to develop the mine. This includes buying equipment and paying salaries, and is simply a part of the production process of the construction company. At the end of this first phase, a fully operational mine is ready to start production, and the invested capital is C_0. The second phase then starts, with expenses consisting of salaries and interest payments, and revenue, c, from the sale of the coal. However, in this case the revenue is greater than the salaries and interest payments by an additional amount, e, which is the value of the coal “in the ground”, and in the revised diagram in Fig. 2.5 that is shown as flowing directly into the Capital processes, where it increases C and becomes available for investing in another project, just as the capital C_0 was generated by a previous project. That is, the simple picture presented in Fig. 2.5 indicates the value extracted from the environment in the form of non-renewable resources, such as land for agriculture, oil, gas, coal, and minerals, as an injection, e, into the capital processes that is independent of the Production processes.

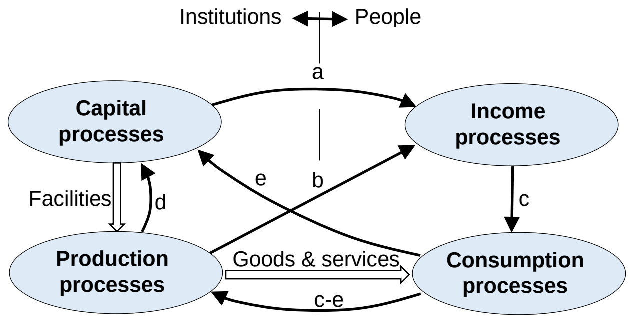

Figure 2.5 A slightly expanded version of Fig. 2.4, showing the value extracted from non-renewable resources as the flow *e*.

This picture needs a correction and a comment regarding the system dynamics. Because the capital is represented by (invested in) facilities, it is subject to deterioration, or depreciation, at a yearly rate of, say, q. That is, the monetary flow q·C is simply lost within the Capital processes; it does not go anywhere, and is therefore not shown explicitly in Fig. 2.4. Furthermore, it is normal to separate the rent paid for the facilities, i.e. the interest on the capital C, from what we identified as the profit, so if we denote the interest by p·C, the profit, *s*, is just the difference, $s = d - p{\cdot}C - q{\cdot}C$, and the Capital processes are as shown in Fig. 2.6.

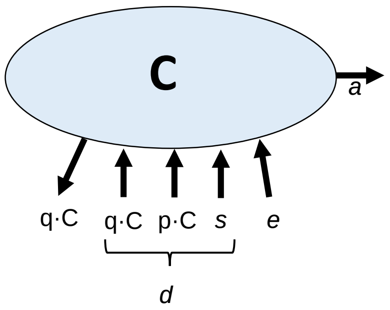

Figure 2.6 The inputs to and outputs from the Capital processes. Here q is the depreciation rate, C is the capital, p is the interest rate (cost of capital), s is the profit, e is the capital injected by exploiting non-renewable resources, and a is the income derived from the capital.

Consequently, the rate of change of C is given by

$$\frac{dC}{dt} = p \cdot C + s + e - a \,. \tag{2.1}$$

Here p·C + *s* + *e* is the capital generated per unit time (e.g. per year) by society and *a* is the amount of that capital flow that is extracted and used for consumption; the difference is invested and leads to growth of the economy.

We therefore see that, if *a* and *e* are constants, the steady state value of the capital is given by

$$C = \frac{a-s-e}{p} \stackrel{\text{def}}{=} \frac{u}{p} \,, \tag{2.2}$$

which is only valid for $u > 0$, or $a > s + e$. That is, in order for there to be a steady state, the income derived from the capital must exceed the sum of the profit and the capital injected by exploiting the non-renewable resources.

The new parameter *u* is the difference between the flow of value representing the return on the investment, *a*, and the flow of profit from the Production processes, *s*, plus the flow of value extracted from the environment, resulting from the depletion of non-renewable resources, *e*. If *a* = *s* + *e*, no capital is required; the return is simply the depletion of the resources. This also reflects our definition of the capital, C, as the capital required for the Production processes, i.e. for the value added processes.

Let us now see how the system behaves if the investors in the Income processes decide to vary *u* from a steady-state value, say, in the manner $u(t) = u_0 + \delta$ for t > 0 and $u(t) = u_0$ for t ≤ 0, and thereby change the relationship between consumption and investment. We then have the linear differential equation

$$\frac{dC(t)}{dt} = p \cdot C(t) - \delta - u_0 \tag{2.3}$$

and, for t > 0, its solution,

$$C(t) = C_0 e^{pt} + \frac{\delta}{p} + \frac{u_0}{p}\,. \tag{2.4}$$

The factor C_0 is determined by the requirement that, as t → 0, C(t) must approach the value given by Eq. (2.2), so that

$$C = \frac{\delta}{p}(1 - e^{pt}) + \frac{u_0}{p}\,. \tag{2.5}$$

The function C(t) is shown in Fig. 2.7, and it illustrates that the steady state of the economic system is unstable; a small increase (or decrease) in *u* results in an exponential decrease (or increase) in the capital, C. Changing C requires a dynamic management of *u*. And, of course, if at any point in the evolution we want to stop depleting the non-renewable resources, i.e. *e* = 0, then the equilibrium condition is *a* = p·C + *s*.

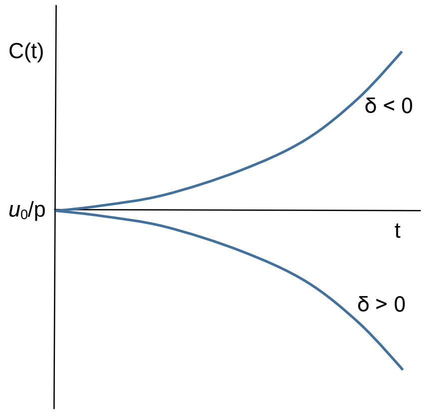

Figure 2.7 Illustrating how the steady state of the capital C, with its value of u_0/p, is unstable; a small change, δ, in the parameter *u* leads to an exponential change in C(t).

To relate our model to available data, we identify *c* as the Gross Domestic Product (GDP) of the society in question, and introduce what is known as the Gross Capital Formation, γ, which in our model is represented by dC/dt/c. Furthermore, we introduce a function *g*, defined as C/c, which we might consider to express a capitalisation ratio. Inserting this into Eq. 2.1 yields the following expression for *g*,

$$g(\alpha, \gamma, \omega; p) = \frac{\gamma - \omega + \alpha}{p} \ , \quad (2.6)$$

where we introduced the normalised variables α = *a/c* and ω = ε + σ, with ε = *e/c*, and σ = *s/c*. The quantity ε + σ, which we for convenience denoted by ω, is the rate at which the Capital processes generate a surplus, i.e. a value beyond the normal interest on the capital, p. Furthermore, we shall make the reasonable assumption that the relative change in C over one year, ΔC/C, is approximately equal to the relative change in c, Δ*c/c*. That is, the growth of the economy can be expressed equally in terms of the capitalisation or in terms of the GDP.

To get a feel for what our model expresses, let us look at an actual case: the world economy. A typical value for p is 0.03 (remember that we are dealing in constant monetary values, i.e. as if there were no inflation). For the year 2013, the World Bank gives a value of Gross Capital Formation of 22% of GDP, or γ = 0.22, a GDP of about 75 trillion $US, and a value for Δ*c/c* of 0.02. With these values, we find that *g* = 22/2 = 11, and that C = 825 trillion $US.

Accepting these values for p and γ, the function *g* becomes a function of α and ω, and it is shown in Fig. 2.8

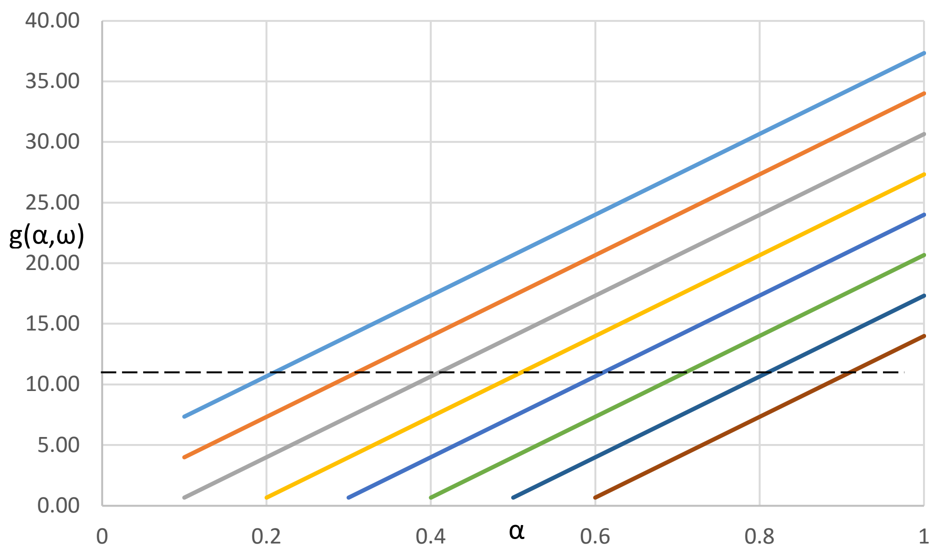

Figure 2.8 The function *g*(α,ω;γ,p), which is the capitalisation ratio, for γ = 0.22 and p = 0.03. The lines are for ω values 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, and 0.8, from top to bottom.

For these parameter values, we obtain the relation

$$\alpha = 0.11 + \omega \ , \quad (2.7)$$

which just expresses the coordinates for the intersection of the g = 11 line with the ω lines in Fig. 2.8. We could also ask what it would take to stabilise the capital at its present value, and Eq. 2.2 then provides the expected answer,

$$\alpha = 0.33 + \omega \ , \quad (2.8)$$

as the difference between Eq. 2.7 and Eq. 2.8 is exactly the increase in C/c.

The parameter α expresses the fraction of GDP that arises from ownership of capital, whether in the form of infrastructure or non-renewable resources.; the rest of GDP is provided by labour, represented by the value flow *b* in Fig. 2.5. In an underdeveloped society, the value of α will be small, but as the society develops and the capital creation, represented by the parameter ω, increases, the value of α increases, and the importance of labour in the economic process decreases. The situation here is that, as Eqs. 2.7 and 2.8 show, in order to reduce or even stop this increase in capital over labour, the expenditure on consumption should increase. But the problem is, of course, that the part of the population that is investing is the part that already is able to spend more or less as much as it likes. This is illustrated, in the case of Australia, in Fig.2.9, and Australia is a reasonably egalitarian society.

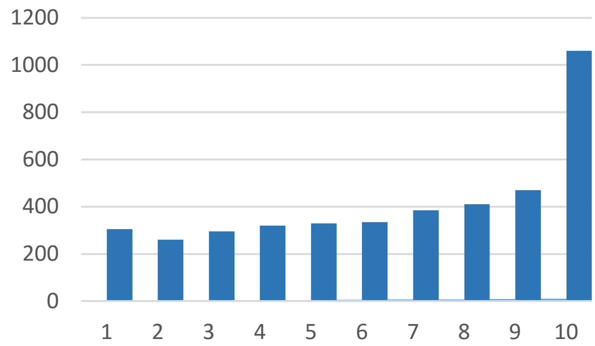

Figure 2.9 Per capita worth, displayed against income deciles, for Australia (adapted from Australian Statistical Yearbook 2012). Values are in thousand Australian dollars.

An even more striking illustration of this situation is provided by the data presented in Table 2.1, which shows the distribution of the net amount of income-producing capital in Australia in 2012. That is, the value of owner occupied dwellings and such items as private cars and boats is not included.

Quintiles, by disposable income				
1	2	3	4	5
-4	-45	8	134	1274
Net income-producing capital, in AU$'000				

Table 2.1 The net income-producing capital, per capita, by quintiles of disposable income, for Australia in 2012 (adapted from Australian Statistical Yearbook 2012).

This issue of the changing balance between labour and capital, its accompanying increase in the inequality in the distribution of wealth, and how it is driven by the increasing application of technology, is a major issue in the recent evolution of society. It is clear that the current mode of capitalism cannot continue indefinitely; how and when it will change is something we shall consider in Chapter 3.

We should note that $\omega = \varepsilon + \sigma$, and it is only σ that reflects the application of technology; whereas ε arises simply from the exploitation of non-renewable resources. So the level of economic development of a society should be measured in terms of σ rather than ω or α. For example, Saudi Arabia would have a small value of the ratio σ/ω, whereas Switzerland would have a value close to 1. Also, a high value of ε can disguise a low value of σ, as has been the case e.g. in Australia.

From this simple view of society in terms of economic processes, we should take the following points with us as we continue to develop our story about the evolution of society:

1. Society, as an economic process, does not have a stable steady state. It is a process that needs to be actively managed in order to go through a desirable evolution.
2. As a society develops, there is a shift in the relative importance of capital and labour, and so we would expect a similar shift in the considerations of social equality and stability from the remuneration of labour (e.g. minimum wage) to the distribution of capital.
3. A major characteristic of this shift is the increasing presence of technology and its applications in the economic process.
4. There is a significant difference between the labour processes and the capital processes (i.e. in "inner" and "outer" cycles in Fig. 2.5) in that the latter contains a reservoir in the form of the capital, C. That is, the return on capital is in the form of a rate, p·C, whereas the return on labour is immediate. Consequently, we expect the dynamic behaviour of the system to change with the shift in relative importance of capital and labour, reflecting the general feature of systems with regard to external interactions we highlighted in the beginning of this section.

Technology – a component of society

As we already discussed briefly in the previous Chapter, technology has been one of the major measures of evolution throughout Phase Three, and today its impact on our society is both undisputed and very obvious. Just take a look around you, and almost everything you see owes its existence to applications of technology. If you are reading this monograph in a printed version, the paper on which it is printed was produced by a highly sophisticated process that converts woodchips into a fibrous "soup", which is spread out as a thin layer on a moving cloth that drains off most of the moisture and delivers a continuous sheet of felt-like material to a highly sophisticated machine, where it is pressed and dried by passing through numerous hot pairs of rollers at high speed. The steel used in this machine was produced in a complex process using iron ore and coal as its raw materials, and by many individual pieces of equipment, each one itself the product of a long development and improvement process. These raw materials were excavated, crushed, washed, and transported by numerous, high performance machines, and so on; a chain that goes on almost without limit. Or take an ordinary drinking glass; the numerous applications of technology involved in converting quartz sand into a finished product at a cost of a dollar or less per glass are each based on a huge body of knowledge. Or the incredible precision required in the manufacturing and operation of the weaving machines that produce the cloth we wear. The involvement of technology in our daily existence has become so ubiquitous that it is no longer given much thought, in the same way that we take our natural environment for granted; as something that is simply there.

And it is exactly this ubiquitousness that is the core of the problem when it comes to considering both technology and the environment. But while there is a great deal of discussion about the extent to which we are responsible for changes to the environment, there is no doubt about that we are solely responsible for every development and application of technology. Technology does not harbour any inherent force that determines its development and that makes its increasing influence in our lives inevitable. We control that development, the problem is that our view of the effects of technology have been superficial, in the sense of concentrating on the immediately visible effects, such as the economic effects, or the effects on power projection, or the effects on physical health, and so on. What has had much less scrutiny is the effect on the structure and fabric of society itself. As an example, we have now seen a number of cases where military superiority is used as a means of suppressing a problem, starting perhaps with Palestine/Israel, followed by Vietnam, Iraq, Afghanistan, and now the whole Middle East. (And the use of technology as a means of suppression is now creeping into our own societies in the form of surveillance, enforcement, and an associated legal framework.) Technology is increasingly allowing one side to inflict grievous losses on the other side with minor own losses, and so this is seen as a relatively easy and, unfortunately, also popular approach to suppressing a problem without having to address the much more difficult task of reducing or eliminating the cause of the problem.

The lack of understanding of, and concern with, the influence of the application of technology on the evolution of society displayed by the general population does not mean that there has not been a significant amount of thought and effort expended on this issue. As we mentioned briefly in the previous chapter, the concern with what might be broadly subsumed under the concept of technology goes back to the Greek philosophers, and from about 1800 onwards, there was a slowly increasing awareness of the applications of technology as significant factors in society. A good review of this developing awareness and of the major issues under discussion is given in the book *Streit um die Technik*, by Friedrich Dessauer, most of which was first published in 1926 under the title *Philosophie der Technik*, and in its final form in 1956. It is, unfortunately, only available in German, as is much of the literature on this subject in the years before World War Two, but reviews can also be found in many of the works listed in References at the end of this monograph. The main point, as far as our story is concerned, is that most of this work was concerned with the effect of mechanisation on the role of workers, transforming artisans and craftsmen into operators of machinery, without addressing the impact of technology on the development of the fundamental nature of society. There were, certainly, exceptions, such as Karl Marx and Thorstein Veblen, but it was only after the appearance and explosive growth of information technology (IT) in the years following World War Two that the influence of technology on the evolution of society became an object of study in its own right, with contributions from philosophy and various branches of social science. A substantial body of work has evolved, and for those readers that would like to examine this further, a number of useful references are given the References. Here we shall only give a brief overview, with emphasis on a couple of aspects of particular interest to the further development of our story in Chapter 3.

The interaction between technology and society is a complex subject, with numerous components and aspects, and one on which the view has changed significantly over time. Much of the early work on the influence of technology regarded it as taking part between two separate spheres of existence; a genuine (or intrinsically, or unsullied) human sphere and a sphere in which technology is prevalent. Technology was seen as developing under its own imperative, and so the interaction was a one-way process, with conflicts arising at the interface between the two, and with humans sometimes seen as the “victims” of technology. More recent work sees the interaction as a process that is both two-way and so dynamic that it is not possible to make a clear-cut distinction between humans and technology. Humans are always hybrids of supposedly human and technical aspects, and what is of interest are the different kinds of human-technology interactions. This is treated in an article by Dorrestijn, to which we shall return in Chapter 3 in a discussion of the relationship between value and ethics; in the present context it is interesting to note how this two-way process is reflected in the system introduced in the beginning of this section. All of the actors in this system (or actor-network, as it is also called) become hybrids, and so there is a feed-back between technology and society that makes the relationship between them take on a dynamic character.

This can be seen, for example, in the importance of a collective readiness to accept and try out new ideas when they become available. This sensitivity to invention is a compound of many social, political and cultural factors, sustained by tradition and passed on by education and training. A well-known example is the stagnation of technological development in Chinese civilization under the control of the mandarins. Up until, say, 1400, Chinese technology and its applications were on a par with, if not superior to, technology in Europe, but in the following centuries European technology developed rapidly, whereas in China a veneration of tradition and ritual by a centralised government stifled development. Some measure of political liberty, a degree of freedom from the constraints of class and conformity, a tolerance towards unfamiliar and even apparently bizarre points of view are all parts of the “social package” required for technology to develop. This was again demonstrated in the relative rates of industrial development in France and England during the period 1600-1800, when an entrepreneurial middle class in England had considerable freedom to develop new industries, whereas in France such development was mainly the prerogative of the nobility, under the control of a powerful monarch.

A distinct body of research is what is identified as the social shaping of technology (SST), and a seminal work here is the book *The social shaping of technology,* edited by D. MacKenzie and J. Wajcman. The point of departure of SST is to acknowledge the much greater complexity of the socio-technical interface than is recognised by either technological determinism, which saw technology developing according to an inner logic, or social determinism, which saw technology development as reflecting a single influence, such as an economic imperative. Central to SST is the concept that there are choices (although not necessarily conscious choices) inherent in both the design of individual artefacts and systems, and in the direction or trajectory of innovation programmes. Different routes are available, potentially leading to different technological outcomes, and they could have differing implications for society and for particular social groups. Rather than merely assessing the social impacts of a given technology, SST examines what shapes the technology which is having these impacts – its artefacts and practices – and draws together views from different areas of sociology and economics to form a deeper understanding of the innovation process and the social factors influencing it.

An important critical strand within SST has highlighted the politics of technology. Technologies can be viewed as "politics pursued by other means" or as the outcome of social conflict; in either case, technologies are not neutral, but are fostered by groups to preserve or alter social relations. Of particular interest to our investigation is the promotion of the Weberian class conflict perspective by proposing that the ability of a society to favour technical change is enhanced by conflicts taking place in a large number of arenas. The nature of the conflicts may be economic competition or social conflicts, and the arena might be industry, a profession, or a neighbourhood, but in any case, in a totally homogeneous society new technology will not be easily introduced, and technical change is more likely to occur in a society or an arena in which power and influence are unequally distributed among a relatively large number of agents.

Closely related to SST is what is known as Social Construction of Technology (SCOT). It is based on an approach called the Sociology of Scientific Knowledge (SSK), which considered scientific knowledge as arising from the socially influenced interpretation of scientific discoveries. SCOT studies technological artefacts and explains how social factors entered into the particular choices among a number of possible ones. One aspect of this social constructivist program, and which is relevant to our story, is that a problem is closed when the relevant social groups see it as being solved. But this is certainly not true in general; in many cases closure simply means that the differences between social groups have been reduced to the point where power relations of a political or economic nature make any further development futile. Thus, closure does not mean the elimination of conflict, and it is the suppression of latent conflicts through power relations that reduce the stability of a society, as we mentioned above.

Central to all considerations of the influence of society on technology, whether explicitly or implicitly, are the processes by which this complex system we call society forms its opinions about technology, and how these opinions are expressed through various components of the system, such as individuals, special interest groups, and professional associations. The most general and basic process is that of the *public discourse*, a very complex and ill-defined process utilising person-to-person interaction and one-to-many interactions through social media and public media (newspapers, radio, and TV), as well as various public discussion fora. How exactly opinions and assessments are formed and grow using these communications channels is difficult to describe, but various aspects of this public discourse, including its effectiveness in influencing the development and acceptance of applications of technology, have received considerable attention.

In the article *Technology's Challenge to Democracy: What of the Human?,* Nikolas Kompridis discusses a number of aspects of the public discourse that are highly relevant to our purpose. It is centred around the question “What does it mean to be a human being?”, posed in response to the risks presented by genetic intervention into the basis of human life. After pointing out how this essential question is being sidelined by the current naturalistic and anti-essential stance of European and Anglo-American philosophy, it sets out a program for challenging technology through the democratic process of public discourse. He recognises that “scientific experts, market imperatives, and the culture of liberal democracy all contribute to a conceptual framework from within which it is extremely difficult to think about technological development except as the welcome expansion in the range of choice available to formally free and equal individuals”. The issue here is not the expansion in the range of choice, but what our criterion is for making the choice, and the process used for establishing that criterion. The current focus is on risk reduction, but the definition of risk is “consequence of not achieving the desired outcome”, so that without an agreed definition of what constitutes “the desired outcome”, such efforts are at best *ad hoc*. That is why “the debate about these new technologies should not be restricted to a debate over appropriate normative regulation. That would be to lose the battle even before it began. … Surely we must be given an opportunity to consent to, or dissent from, so spectacular and irreversible change as the alteration of our biochemical nature. But more importantly, we must be given an opportunity to pose the question ourselves, prior to having it settled by “experts”, scientific or otherwise”. He quotes Habermas in support of this view, and generalised to the introduction of any new application of technology, this resonates strongly with the concept of the importance of being able to exercise our intelligence, which we shall develop in the next Chapter.

Kompridis then goes on to propose a counter science of the human based on the concept of the person as a being for whom things matter, and matter in a peculiarly human way. And, in particular, what matters, and which constitutes and sustains personal identity are our relations with others. This does, to a large extent, reflect our view of the individual as an element of a system – society – and that the importance of the individual arises from its contribution to the behaviour of society as an emerging property through interaction with other individuals.

The last part of this thought-provoking article describes and advocates the process of public discourse, setting out two main conditions for such discourse to be meaningful: “First, we need to ensure that democratically organized processes of public reflection can take place in both official and unofficial public spheres, maximising the opportunity for citizens to speak and be heard, to listen and learn. Second – and this is far more challenging – we need to develop, and to comfortably speak, evaluative languages not already structured by the presuppositions of the language of progress, which does not allow us to be critical of progress without appearing to be politically and morally conservative, and so, without appearing to be against science and against reason.” The importance of effective use of language in conveying the information required for assessing applications of technology has been highlighted by various authors, and will appear again as our story develops in Chapter 3.

Similar thoughts are expressed by Marx Wartofsky when he poses the central question: Given that technology so decisively affects the lives and futures of people, nationally and globally, and since policy decisions are now on such a general political scale as to become largely national and international governmental decisions, can the democratic imperative of self-government by the people be effectively carried into the arena of such technological decision making? For this, which he calls the fourth revolution, to happen, two major changes will have to take place: the democratization of power in society, and the education of the scientific and technical understanding of the public, both to the extent that some form of democratic participation in scientific-technical policy-making becomes feasible and useful, and not simply an empty populist piety.

The importance of democratising the assessment of technology has been emphasized by a number of authors. For example, Andrew Feenberg states: “Technologies form the framework of our lives, but they are designed with little or no democratic input. This is a serious failure of our institutions. It must be addressed by reforms in education, the media, the corporations, law, and the technical professions." And Ian C. Jarvie says: "The most important philosophical problems of technology are, then, social and political ones. Neither in civilian use, nor in military and clandestine use, is there remotely adequate input from the general public about technology, its costs and its benefits."

The last couple of decades have seen a growing interest and activity in what is known as participatory technology assessment (pTA), particularly in Europe, where it has been supported by such government bodies as the Danish Board of Technology and the Rathenau Insititute. It has given rise to various networks, such as Living Knowledge: The International Science Shop Network. Closely related to this is the rise of mass-mediated expertise, which allow citizens to become involved in expert deliberations on science and technology issues. A German study by Petersen *et al* supports the hypothesis that mass-mediated expertise has a significant impact on policy processes, whereas a survey on *The Impact of New Technology on the International Media and Foreign Policy* by Hopkinson found that the influence of public opinion (and of the media) was less that often thought, as public opinion is often incoherent. It is dependent on the particular case, but in general most important when the government is weak. A cautionary note is also sounded by Gabriele Abels when she asks: "Can strategic actors become interest-free deliberators? Why should they restrict themselves to contributing expertise, if they can mobilise other channels of influence to lobby for their interests? What about the danger of stakeholder capture?".

A recent article by Hennen makes a strong case for pTA, stating "pTA should fundamentally be considered an element of what Sheila Jasanoff has termed "civic epistemology". The emphasis should be on "an element", namely as an element of the manner in which societies adapt and value scientific knowledge. In this regard, it is one element among several that are decisive, some of the others being the forms of political representation, the role of experts in the political system, the culture of public deliberation, and the degree of transparency in public institutions. It is a deliberative element of the organization of the way in which society treats knowledge, not an Aristotelian point to turn the system upside down".

Due to the strong and ubiquitous interaction between ICT and society, as already mentioned, the presence of ICT in the structure and functioning of society can be considered a defining characteristic of society, and one speaks of *the information society*. Here we should distinguish between two types of theories about the impact of ICT on society: those that focus on the direct impact of developments in ICT on politics and culture, and those that focus on the impact on the economy or mode of production. With regard to the former, there is an almost euphoric view that problems of social and cultural inequality can be solved and barriers to full political participation removed by technologies for the production and distribution of information. Put the processes of democratic politics on-line and full political freedom will be achieved. Put University and school courses on-line and the age of universal education will finally arrive. And with regard to the latter, people like Daniel Bell have argued, based quite explicitly on both Marx and Weber, that post-industrial society is developing in stages. Capitalism is moving from a stage of industrial capital based on the exploitation of matter and human energy to a post-industrial stage based upon the exploitation of what Bell called "organised knowledge". The core resource has shifted from monetary capital to knowledge.

Several authors have pointed out that what we are witnessing is a second "industrial revolution", in which an increasing number of human activities in all fields are being taken over by IT. Kevin Robins states that the past history of multinational corporations gives little promise that they will have democratic interests at heart in the future. For them, IT represents just another series of exchange values which by no means correspond to real social needs, and they have shaped it - without democratic participation and consultation – to express specific corporate values and priorities. There is no reason to believe that IT will not reinforce, and aggravate, existing inequalities at both national and international levels. He quotes Schiller as saying "contrary to the notion that capitalism has been transcended, long-prevailing imperatives of a market economy remain as determining as ever in the transformation occurring in the technological and informational spheres", a view that is further detailed by Schiller, who argued forcefully that the current role of the media in modern society, and in the US in particular, is to support the capitalist economy and suppress any meaningful debate on alternatives.

A similarly sobering view with regard to the impact of ICT on society, and one that we should keep in mind, is that put forward by Nicholas Garnham in a number of publications. He makes the observation that much of the talk of an Information Society is just the Service Economy relabelled, and that arguments about ICT having caused an epochal shift in either economy or society are largely specious. He challenges the view that the information technology will usher in a new era of cultural freedom, diversity and abundance and shows that we are here in the presence of ideology in its pure, classical form; that is to say, a social analysis that not only misrepresents its object of analysis by focusing on its surface rather than its underlying structure and by denying its real history, but also misrepresents it in such a way as to favour the interests of the dominant class. In this case, the trick is played by concentrating upon the technical potentialities, rather than upon the social relations that will determine the form in which those potentialities are realised and by denying history by exaggerating the novelty of the process in question. We are witnessing merely the latest phase in a process integral to the capitalist mode of production; an "industrialisation of culture" or "colonisation of leisure" by which massive market interests have come to dominate an area of life which, until recently, was dominated by individuals themselves.

Garnham then discusses the growing information gap in western societies, between the information-rich and the information-poor, and how this is related to the widening gap between rich and poor. Also, the information technology is structured to reinforce this, splitting the culture into two classes. Choice, being increasingly expensive, is offered to upper-income groups, while an increasingly impoverished, homogenised service is offered to the rest. Eventually, we will have to choose between two social forms. On the one hand, we can choose a society which primarily fosters social relations, based upon the Aristotelian notion of men and women as essentially social animals, based therefore upon notions of social reciprocity and interchange, upon the public as opposed to the private as the essence of humanity. Without such a notion, politics in any true sense is unthinkable. On the other hand, we can choose (or more likely have forced upon us) a society which is merely a social structure within which atomised, privatised individuals interrelate, primarily through commodity exchange, and by so doing necessarily reproduce the dominance of the capitalist mode of production and of those who control it, namely the owners of the means of production. Such a society will necessarily subordinate the public to the private sphere and destroy politics in favour of a manipulative form of elite control if we are lucky – what Bertram Gross has dubbed 'Friendly Fascism". These latter tendencies will be powerfully reinforced in the cultural sphere by the introduction of information technology under market conditions. Such introduction should therefore, as far as possible, be opposed.

An interesting view, although somewhat peripheral to our purpose, is represented by a very significant body of work within sociology that treats the relationship between technology and society. This work is clearly related to the subject matter of this monograph, but there are some significant differences, and the first of these is the meaning and treatment of "technology". Most of the items of this body of work do not contain any definition of "technology", and where there is an implied definition, such as in the Introduction to the already referenced book edited by MacKenzie and Wajcman, the relationship of society to technology is seen as a relationship to things. And while engineers are mentioned, there is relatively little interest in how engineers relate to technology. Nor is there much discussion of the relationship between industry and technology. It appears that sociologists view technology mainly as a "black box", relying on our intuitive and everyday understanding of the concept, and focus on its external interactions.

This is in marked contrast to their treatment of society, which is considered to be a complex system and subjected to a variety of views, such as gender, social status, education, power, etc.

And so, this deeper understanding of the nature of society on the part of sociologists and the better understanding of engineering, industry, and the internal workings of "technology" on the part of engineers could be an area of fruitful collaboration between the two disciplines.

Sociologists also appear to take a more pragmatic approach than do philosophers; they do not worry so much about if something is "good" or "bad"; they are mainly interested in understanding how it works. How does technology influence society, and *vice versa*? And so they view the world as a giant laboratory in which experiments are going on all the time, and they observe, record, and analyse. The result is numerous and varied valuable insights into the interaction between society and technology and, in particular, the understanding that this is a two-way interaction; something that resonates strongly with the view developed in this monograph. Quoting again from MacKenzie and Wajcman, the view that technology just changes, either following science or of its own accord, promotes a passive attitude to technological change. It focuses our minds on how to adapt to technological change, not on how to shape it. It removes a vital aspect of how we live from the sphere of public discussion, choice, and politics.

Finally, when considering the influence of technology on public discourse, it is important to distinguish discourse, which implies an active involvement of the participants, from the (often one-sided) provision of content. Technology has, on the one hand, provided unprecedented possibilities for engaging in public discourse; on the other hand, it has led to both an information overload and to a mixture of products, facts, opinion, and advertising being presented in a manner that makes it difficult to differentiate between them. One result is that we have become media-rich and information poor, another is that culture has become a commodity. As far as public discourse is concerned, the result is a sidelining in favour of the commercial interests of the media owners.

A detailed, if perhaps not entirely unbiased account of the relationship between technology and society is given by Naomi Klein in her recent book, *This Changes Everything*. It is focused on the environmental impact of the carbon-extracting applications of technology, such as fracking and tar-sand processing, and on the crisis of global warming, but – without in any way downplaying the magnitude of this crisis – the major significance of this work in the context of the present investigation is Klein's clear understanding that it is not technology itself that is the problem. The problem is the application of technology through an industry that is locked into the capitalist "free" market economic system and an associated system of values expressed through an addiction to things and consumption, to the neglect of social and moral values and the importance of interpersonal relations. She also illustrates, through numerous examples, the illusion of the "free" market, and promotes the understanding that the socially beneficial operation of a market can only take place with a significant amount of regulation and intervention by government (to the extent that it represents all of society).

The role of industry

Now, after this brief review of a small portion of the body of work that has been produced on the interaction between technology and society, we want to focus more specifically on the processes by which technology is actually developed and applied. In particular, this means focusing on the entity where these processes take place, which is *industry*, and to this end we adopt the same top-down approach that we applied in the process view in the previous section. But in our first level break-down we adopt a partitioning of society as a system in a manner that is particularly suited to providing a "macroscopic" view of the process by which technology and society interact, as shown in Fig. 2.10. It may at first seem peculiar that one of the subsystems is labelled "society", but it reflects what was mentioned earlier, that people, as the fundamental building blocks of society, may take on more than one role. In particular, in addition to their main role as members of society, they may take on roles which then define identifiable *functional* entities within society.

In our case, that entity may broadly be identified as industry, but there are many other possible entities, such as government, law-and-order enforcement, the health system, defence, and the like.

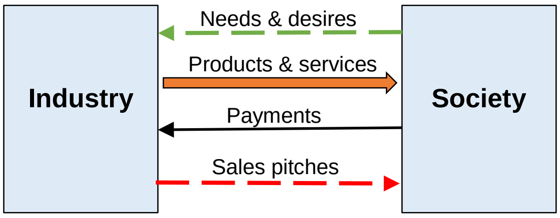

Figure 2.10 The interaction between industry and society.

While the picture presented in Fig. 2.10 is very high-level, hiding many important features of the interaction between industry and society, it does emphasize that this is a mutual, or two-way, interaction, as already noted. In order to meet an actual or perceived need (shown in green as the colour of hope) by a group or all of society, industry will develop technology and apply it in the form of a service or product. Society then decides the degree to which it will accept this new application, and expresses this acceptance in the form of payment, thereby providing a feedback to industry. In addition, industry will make pitches to society for additional products and services (shown in red as the colour of temptation) that reflect either a capability that industry wishes to exploit or a latent need or desire that industry perceives within society.

Let us first look more closely at the entity we have labelled industry. The activities performed by industry, and which together constitute the *industrial process*, are expressed in the form of individual *projects*. In the context of a specific project, industry encompasses everything directly involved in executing and completing that project. The inclusion of the word "directly" is important, and for now an intuitive understanding is hopefully adequate. For example, the machine tool operator that goes to work every day on the project is directly involved, whereas his wife, who stays at home and manages the family life is only indirectly involved. The debt provider (e.g. bank) is directly involved, whereas the people who put their savings into the bank are only indirectly involved.

Of the people directly involved in projects, *engineers* play a particular role when it comes to the interaction between industry and society. Engineers are largely responsible for the development and application of technology, and understanding their involvement in the industrial process is essential to understanding the interaction between industry and society.

It is possible to distinguish two broad groups of projects: projects that utilise the existing resource and knowledge bases to meet a *need* expressed by all or a part of society, and projects that increase the resource and knowledge bases. Or, in other words, projects in the first group *apply* technology in order to meet requirements imposed by entities or people who are generally not engineers, and it is these stakeholders that are the judges of project success; whereas projects in the second group *develop* technology, often using that part of the knowledge base that is provided by science, but sometimes also based on heuristics or arising from trial-and-error, and their success is judged generally by other engineers. Let us agree to call these two groups of projects *application projects* and *development projects*, respectively. There is not a sharp boundary between these two groups, and there will be many projects that contain sub-projects of both types, but as we are concerned with the influence of technology on society, we are mainly interested in projects in the first group.

The meaning of "industry" in a general sense, without reference to any particular project, is then simply everything directly involved in executing and completing projects. This industry has an internal structure; it consists of legal entities called *enterprises*, and examples of such enterprises are private companies, public companies, sole traders, incorporated joint ventures, and government bodies or corporations. Projects are carried out within a legal framework created by the enterprises directly involved in the projects and the interfaces between them, which take the form of *contracts*. The nature of this framework varies significantly, from the case where multiple projects are performed completely within a single enterprise to the case where a single project is performed through the involvement of numerous enterprises in a framework containing several types of contracts, such as alliance contracts, lump sum contracts, and cost-plus contracts. This framework defines not only who does what, how, and when, but also who carries the liability for the various possible deviations from the agreed project performance.

Within this framework, each engineer is employed by an enterprise. This is also a contractual relationship, defining rights and obligations of both parties. Besides requirements for ethical behaviour, a central requirement is for the engineers (as for any employee) to support the aims of the enterprise. Irrespective of other aims, the aim of any enterprise must be to make a profit, without which it will generally not survive. Thus, the individual engineers on a project find themselves enmeshed in a set of relationships and requirements that may be complex and, in many cases, somewhat contradictory. This issue has been identified by several authors, notable among them Thorstein Veblen, Langdon Winner, David F. Noble, and Edwin Layton.

An important aspect of the relationship between engineers and society is *alienation*; a concept attributed to Hegel, but developed in much more detail by Karl Marx, as described and analysed by Wendling. Marx was concerned about the alienation of workers (or the proletariat), but the analysis provided by Wendling is highly relevant to the present work; we just have to specialise workers to engineers and capitalism to industry. Basically, alienation means that humans lose (or are alienated from) part of their essence as humans by the conditions in which they find themselves, and in the case of engineering, engineers are being alienated from the essence of engineering, which most definitions of engineering manage to capture in a more or less satisfactory manner as the development and application of technology for the benefit of mankind, by being embedded in industry. Industry has its own ideology and norms, described by such concepts as profit, value, turnover, growth, return on investment, efficiency, loyalty, and so on, and as long as these norms appear as natural features of society, rather than as something imposed on society, there is little incentive for engineers to question their current role or these norms.

Central to understanding the industrial process is the realization that its function is to meet a set of *stakeholder requirements* on a project. The engineer attempts to meet that need by creating an object that meets the relevant part of the stakeholder requirements and, when put into operation, provides a *service* that meets the need. The judgement of the stakeholders as to the extent to which the service meets the need is the measure of the project's success. This industrial process is illustrated in the diagram in Fig. 2.11. The colouring of the entities is intended to indicate that, while engineering plays an important part in the industrial process, this is a process controlled and executed by industry. The degree to which engineers are involved in the entities varies greatly from project to project, and only the two objects coloured blue, design and specification, can be unequivocally ascribed to engineering. That is to say, engineering is a sub-process of the industrial process, and engineers work within the industry structure required to realise a project; a framework that involves many other people besides engineers, including politicians, business men, lawyers, financiers, marketing and sales personnel, technicians, tradesmen, and labourers, so that what society experiences is often influenced only to a limited extent and in an indirect manner by engineers. And, what is equally important: society has little insight into and understanding of exactly what this extent and manner are.

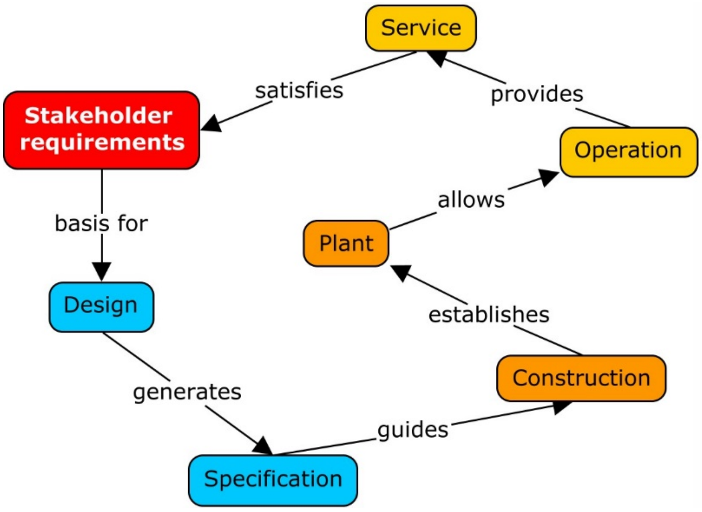

Figure 2.11 The involvement of engineering, indicated by the two blue entities, in the industrial process.

The tensions within industrial projects can be illuminated by viewing the stakeholder requirements as belonging to one of two groups. In the first group are the requirements of the users; i.e. of the people constituting the part of society that expressed the need, and these requirements, plus any requirements imposed by law, should be considered the primary requirements. In the second group are the requirements of the people involved in realizing the project, such as project managers, contractors and investors. These requirements are generally concerned with profit and return on investment, and they should be considered as secondary requirements, in the sense that they are only addressed contingent upon the primary requirements having been fulfilled. However, in some cases it is the other way around; projects are seen primarily as business opportunities, with the user requirements as of lesser importance, a point of view put forward by other authors, such as van de Poel in his work on value-sensitive design.

The main point to take away from this discussion of the role of engineering within industry is the realization that while technology may be developed by engineers, the applications of technology are determined largely by the commercial processes taking place between industry and society, as indicated in Fig. 2.10. While scientists can create great scientific work on their own, engineers can create virtually nothing on their own; creating a bridge or a new microprocessor requires a large industrial organization. The significance of this difference, and the effect it has on the ability of engineers to act freely, is sometimes overlooked by authors that attempt to project the more developed philosophy of science into a philosophy of technology.

The degree of acceptance of a product or service is dependent on a decision by each individual member of society (or group of society), and that decision is based on two sets of criteria: one regarding the relative importance of the particular need compared to the individual's other needs, and a judgement regarding how the offered service or product meets the need. The factors that enter into the decision therefore include the person's socio-economic status, personal beliefs, and current situation with regard to health, employment, inter-personal-relations, and so on, but is also based on the person's understanding of what the features of the product are, including such factors as life cycle cost and health and environmental impact. This is where the responsibility of the people developing applications of technology for providing the information that will allow people to form their own understanding comes in.

Clearly this decision process is, even for a single person, a very complex and dynamic process, and evaluating it for each individual in society is a hopeless task. The approach used to handle this complexity and obtain some quantitative measure of the process has two sides to it. One, the population is divided into groups according to the value(s) of one or more parameters, such as age, ethnicity, wealth, etc. Two, the outcome of the decision process, the level of acceptance, is characterised by a few composite or global parameters. The result is that we have characterisations of the decision process of varying levels of detail. For example, at the least detailed level, we could consider the population to be a single group and express the acceptance in terms of a single, global parameter, such as a fraction of GDP. In other words, the acceptance of a new application of technology could be measured by what society is willing to pay for it, although this is a very coarse and, one could say, simplistic measure. And even expanding it by including non-monetary components of cost, such as damage to the environment, is often not adequate to fully characterise the influence of an application on society, as the previously mentioned use of technology to suppress problems illustrates. In the next Chapter we shall take a different approach and, at least at first, focus on what is common to all people in the way in which they make decisions, and then see what the consequences of this are for society as a whole.

Chapter 3 – The Individual

Some initial thoughts

In Chapter 1 we looked at the evolution of life on Earth in terms of three phases, distinguished by the very different character of the evolution in each phase. In Phase One it was the evolution of species, from simple forms to complex forms, and while there was a process of competition and selection going on, there was also, at any point in time, a web of interdependencies between species, forming a complex and continually evolving ecosystem. With the appearance of the genus *homo* in Phase Two, the character of evolution changed, in that the evolution of this one genus started to progress at an accelerating rate that soon set it apart from the other genera and liberated it from its role as just another component of the ecosystem. The development was one of increasing capability rather than a change of external form, and this capability allowed humans to exploit the rest of the ecosystem as a resource and to isolate themselves to a large extent from the fluctuations in that ecosystem. In Phase Three the character of evolution changed once again. What now evolved at an accelerating pace was the interaction between individual humans rather than humans themselves, and this manifested itself in the development of increasingly complex societies that supported capabilities far in excess of that of an isolated individual.

Chapter 2 was accordingly dedicated to exploring the nature and development of societies. We recognised that a society is a complex system, and that, adopting an approach used e.g. in systems engineering, the best way to handle this complexity is to treat individual aspects of interest as separate views of the society. Each view is in itself a system, with elements relevant to the aspect under consideration. In one of these views we considered various groups of activities an individual could be engaged in, and found that the amount of time that was available for discretionary activities, or so-called “free time”, has been increasing over the last couple of centuries. Together with increasing affluence, this provides the market for the expansion of industry driven by applications of technology. - Another view, of economic processes, highlighted the shift in importance from labour to capital (or ownership), and how the dynamics of this shift is currently driving the evolution of society.

In each view we saw how the evolution of society is closely coupled to the development and application of technology, and how this coupling is a two-way interaction, providing a feed-back mechanism that requires active control in order not to result in a run-away situation. And the influence of technology is evident not only in all the equipment and systems surrounding us in our daily lives, but also in the way technology is changing the fabric of society and, indeed, what it means to be human. This is often expressed by saying we are becoming hybrids, with a nature that is partly determined by technology, but in saying so, we have to be careful not to let this formulation lead us to view an original human nature and technology as two separate items that have been joined in this hybrid. Technology has been a defining aspect of the human species
s from the start; the current challenge is that the rate of development of this one aspect may be outstripping our ability to understand and control it as part of the whole process of evolution.

These two chapters provide the background on which the main part of our story now continues; the story of the role of the individual in evolution – the story of us. It is the continuation of the incredible journey that has taken us from the cave to where we are today in the short span of ten thousand years or so. And we did it! It was not some external force or divine power that drove this development; it was an ability within us. Of course, this focus on our own species, *homo sapiens sapiens*, may in the long run prove to be misplaced. We might manage to create conditions that lead to the extinction of our species, e.g. through high levels of radioactivity or a particularly successful bacterium or virus, and in a hundred million years the dominant species will look back on us as we look back on the dinosaurs – another sidestep in the march of evolution. However, at the moment we are all we have got, so let us see what we can do.

An individual's ability to do something it wants to do will depend on two things: The individual's inherent capability, and the external circumstances in which the individual finds itself. To investigate these, we can refer back to our earlier thoughts about evolution to show that this capability is closely related to intelligence. The evolution of life on Earth has, until recently, been a process of selection between variants generated by genetic mutations, and the selection criterion has always been survival in a changing environment or, in other words, the ability to adapt. That ability has two components. One is the physical adaptation, such as a variant with thicker fur during a period of falling temperatures; what we might call *passive* adaptation. The other is the mental adaptation; the change in the organism that allow it to *respond* to changing situation in the new environment. We might call this *active* adaptation, and this ability is basically what constitutes *intelligence*.

Intelligence is a subject with a long history of study and investigation. There are various definitions of intelligence, but one which has wide acceptance is that the intelligence of an organism is its *goal-oriented adaptive behaviour*. A small sample of only three collections of articles (Sternberg 1982, Wilhelm and Engle 2005, Wolman 1985) demonstrates that the focus of research on intelligence is on understanding, quantifying, and measuring that behaviour, either in a classical "external" fashion through stimulus-response descriptions, which form the foundation of intelligence tests, or in a more recent "internal" fashion that sees the behaviour as the result of information-processing processes. As a result of this latter approach, various process models emerge as models of intelligence. The interesting feature of all these articles is that, while the "adaptive behaviour" part of the definition receives in-depth attention, there is almost no discussion of what the goal of the "goal-oriented" part of the definition is. In the following, a very high-level process model of intelligence is used to advance the argument that the goal has remained the same throughout evolution, only the strategies for achieving it have become increasingly complex.

A high-level model of intelligence

The diagrammatic representation of the model in terms of its main elements and their interactions is shown in Fig. 3.1. The organism responds to the external stimuli representing a new situation by performing an adaptive action. The action is performed by the actuators (feet, vocal chords, etc.) available to the organism, which are controlled by the processes taking place in response to the signals provided by the sensors. The processes are dependent on the knowledge accumulated by the organism through experience and education, and on inherent mental (i.e. instincts) and physical (agility, strength, reach, etc.) features of the organism.

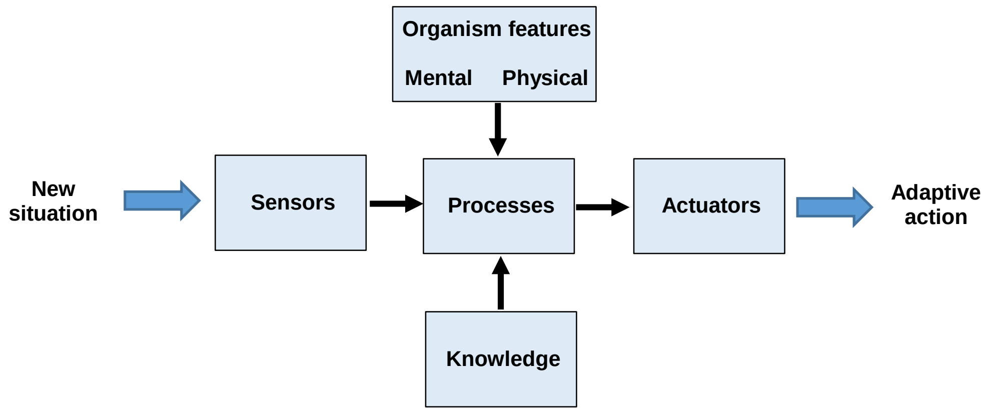

Figure 3.1 Diagrammatic representation of the high-level model of intelligence.

The elements of this model have all undergone great changes during the evolution of life on Earth, and stages of these changes can be observed in organisms alive today. In the early stages all the elements were minimal, and a present-day representative would be a plant. A tree has effectively no knowledge, its sensors can detect the direction of sun and wind and the presence of moisture underground, its mental features are the instincts that tell it to grow towards the sun and to extend its roots towards moisture, and the only actuators are, correspondingly, directing the growth of branches and the extension of roots.

As evolution progressed, organisms became more complex, with more and more capable sensors and actuators, and the other elements of intelligence evolved to take advantage of this development. A present-day example of this stage of development would be a bird. Its sensors include sight and hearing, the actuators are wings, legs, and sound generator, knowledge could include information about flight path between summer and winter habitats, the behaviour of food sources (worms, fish), and instincts include procreation, shying away from larger moving objects and loud noises, among others. The processes are correspondingly complex, allowing the bird to respond to changes in the weather, detect the location of food, etc.

Finally, evolution arrived at *homo sapiens*, perhaps some 5-8 million years ago, and from that time the development of intelligence took a somewhat different route. While the features, the actuators, and the sensors did not develop significantly, the processing capability, and with it the ability to accumulate and use knowledge, changed dramatically. The processing capability is located in the brain, and the size of the brain is a measure of this capability, but to understand the increase in processing power, it is necessary to consider the brain to contain two groups of processes: those required to interface with and control sensors and actuators, and those involved in the cognitive processes of perception, learning and memory, reasoning, and complex problem solving. Various studies and theories of intelligence are based on the idea that the brain weight required for the first group of processes is proportional to some characteristic of the organism's body, such as weight or surface area, and the ratio of the actual weight of the brain to this predicted weight is an indication of the proportion of the brain available for cognitive processes and therefore of intelligence. But many other factors, both physical (e.g. folding of the brain) and organisational (e.g. interconnectedness of regions), also influence intelligence, and a major one is the development of the element we labelled as "knowledge". An essential ingredient in intelligent performance is the storage and retrieval of knowledge in a way that makes it highly accessible and conveniently usable.

In the present context of human society, it is the element labelled "knowledge" that is undergoing the most significant change in the form of an accelerating increase, caused by research, education, and through support by information processing systems and devices. The inherent processing power of the brain is both changing very slowly and does not vary significantly from one group of people to the next. If a newborn child from a tribe in the Amazon basin would be adopted by an affluent family in a developed country and provided with a good education, it would probably do as well as any of its peers. Likewise, the element labelled "Organism features" does not vary significantly with time or between groups of people, and so it is a lack of knowledge that is a major restraint on the ability to determine an appropriate adaptive action; that is, on the exercise of intelligence.

We now need to realise that the circumstances in which an individual finds itself can be divided into two groups. In one group are all the circumstances determined by the physical environment in which the society is embedded, and an example may illustrate what is meant by this. The Aboriginal societies in Australia were embedded in an environment that provided no plants suitable for agriculture (e.g. corn, wheat, potatoes, etc.) and no animals suitable for husbandry and as sources of power (e.g. horses, cows, sheep, etc.). Irrespective of the constraints Aboriginal society placed on the behaviour of the individual and therefore on the opportunity for exercising the intelligence, there would be no effect of doing so, and so the societies remained largely unchanged for tens of thousands of years. - In the other group are what might be called societal circumstances, which include cultural, political, and economic circumstances. They are the circumstances that can be changed by changing society.

The stage of evolution we now find ourselves in can be characterised by two main features of both of these groups of circumstances: One, the rate of change is increasing, reducing the time available for exercising our intelligence and taking adaptive action before the effects of the changes overwhelm us. Two, the changes are generally in the direction of increasing complexity; both groups of circumstances are now significantly more complex than they were only a couple of hundred years ago. And the two groups have something else in common: their relationship to technology. Technology plays a central and rapidly increasing part in their evolution, and the influence of technology on the evolution of society will depend on both of these groups of circumstances, because the effect of a particular application of technology will depend on both the structure of the society and the environment of the society.

The great increase in the complexity of the changes in environment humanity had to adapt to and of the cognitive ability required to handle these changes meant that handling a change required not one process, but a collection of processes, or a *strategy*. And with increasing complexity it becomes increasingly difficult to understand how the individual processes relate to the outcome of the strategy; the outcome is an emergent property of the strategy. Furthermore, the effect of a particular adaptive action within a strategy is not unchanging; it is very much dependent on the state of the environment in which the action is carried out at the time it was carried out.

This description of the current state of evolution might, at a first reading, appear confused or contradictory. On the one hand, we assert that all changes are the result of human action, i.e. governed by intelligence; on the other hand we say that we need to take adaptive action, i.e. use out intelligence, to handle changed circumstances. The resolution of this apparent contradiction will emerge as a result of developing a measure of evolution, in the next section. This measure will allow us to characterise changes as either desirable or undesirable, even though both are the result of using our intelligence, and thus resolve the apparent contradiction as a correction of undesirable changes by desirable changes.

A measure of evolution

No matter how intelligence developed, how this development is characterised by the changes in the elements of our simple model, and the complexity of the current state of development, we can ask what the goal of the adaptive action is. And was this goal always the same, or has it been changing? In the Darwinian theory of the development of the species the goal was the increase in the individual’s ability to survive and reproduce, and this seems to still be the case, although modern biology and genetics have added many refinements to Darwin’s original work. Let us use the term “life” to mean the life of the group of organisms in question, which might be a species, or a subspecies, or a group within a subspecies, and for it to encompass the life of individuals as well as the existence of the group. That is, we do not differentiate between the survival of the individual and that of the group, or between the individual’s sub-goals of survival and reproduction. Then, at least until the advent of modern humans, the ultimate goal was the preservation of life.

Focusing now on the last 10,000 years or so of evolution, there has been essentially no change to the physical features of humans; that is, to all the elements of the model except the one labelled “Knowledge”. That element has undergone a spectacular development under the influence of two related processes. One, the emergence of increasingly complex interactions between individuals, in the form of families, clans, tribes, and nations, but also many other organisational groupings, such as political parties, special interest groups, religious organisations, etc. Two, the exponential growth of technology, which afforded these groups increasing control over their environments and the ability to create numerous artefacts supporting their existence. Thus, in order to characterise a group, it is no longer adequate to describe the individuals belonging to the group, but also the artefacts owned by the group. At first these were items like villages with cultivated fields and herds of animals, then boats, wagons, roads, bridges, castles, mines, and so on, but also such items as a written language, training and education, and a legal system. Calling such a combination of a group of people and their artefacts a *society*, the recent evolution is one of the formation of larger and more complex societies, increasing interaction between these societies, and a decrease in the part of the Earth's resources that is not directly involved in sustaining these societies.

If we look at the life of typical members of our modern society, many of the activities in which we are engaged and which exercise our intelligence appear to have little to do with sustaining life. Art, literature, philosophy, sport, and many other activities, including the practice and involvement in religious beliefs, occupy significant parts of our time, and in some cases people will even sacrifice their lives in support of such activities. So, are we seeing a change in the goal of adaptive behaviour away from sustaining life towards some higher ideal? Is our existence changing from a physical existence to a mental existence, where the purpose of the body is only to sustain the brain, and all physical work is done by robots? To investigate these and similar questions, we need to look more closely at these "auxiliary" activities. Starting with education, the desire to learn, study, and research is driven, on the one hand, by the need to succeed in the competition for positions in the workplace and for the security that comes with wealth and the approval of our peers; on the other hand, by the need to conquer the threatening uncertainty of the unknown. Gaining knowledge is important to survive in the competitive environment of modern society, much as physical strength was important in earlier times. Appreciation of, and involvement in, art, literature, philosophy, and politics; in short, in the intellectual side of society, serve, on the one hand, to enhance our understanding and realisation of our selves; on the other hand, to advance our standing and influence in society. But in addition to our standing as individuals in society, we realise that the strength and vitality of society itself is a foundation of our existence, and so many of the activities we undertake are directly or indirectly in support of society.

What is happening is not that the ultimate goal of the adaptive behaviour is changing; it is that the strategies for achieving the goal are becoming ever more complex. Evolution is no longer the evolution of species driven by genetics; it is the evolution of societies. As societies emerged, there was a balance between individual survival and society survival, with that balance shifting rapidly in favour of the societies. Now it is (slowly) becoming a balance between the individual societies and the world community as a single society. When the latter becomes dominant, it will revert to individual survival under limited resources, and evolution will become the internal changes to this society, driven by intelligence, to preserve life in this environment. Then, as now and as it has always been, the purpose of life is simply – life. Which is not surprising, because what else could it be?

But while society is the entity that evolves, it is the interaction between individuals that determines the characteristics of a society; these characteristics are the emergent properties of the system. An important component of that interaction is the moral component, and through the acceptance of Kant's categorical imperative humanity can, if properly ruled by moral and judicial laws that are held in common, maintain a society that, although thoroughly human, nonetheless represents a harmonious and ordered whole. However, while such a harmonious and ordered whole may be a necessary condition for "the good life", it is not sufficient; the categorical imperative defines what an action must conform to, but does not say anything about what actions one should engage in, or if one should engage in any at all. Similarly with politics; it is necessary for a society in order to manage different viewpoints and desires, but it is not sufficient. For a view of the actions to be undertaken by an individual, we might turn to Nietzsche. Although often reviled for some of his more extreme views, such as "war is good", a recent book by Luc Ferry, *What is the Good Life?*, which is highly relevant to the purpose of this monograph, explores the positive aspects of Nietzsche's view of the most enlarged or valuable life as the most singular, the richest, the most intense life; as a life rich in diversity, but without conflict (Nietzsche's "grand style"). The driver is the will to power, but "power" should not be interpreted narrowly as physical power, but rather as power over one's self; the power to exercise one's abilities to the full. Simplistic, romantic notions of "the good life" as happiness or harmony with Nature, as a cow standing in a field of clover or, as Kant remarked, an oyster in its shell, discount the essential human characteristics of intelligence and will and do not give any meaning or aim to life.

In his book, Ferry explores Nietzsche's view of human life, as we are living it now, in the present, as the proper object of our thoughts. Nietzsche was not an amoral person; he just believed our values should be based on our own analysis and judgement of life as we are experiencing it, not on some external authority or deity. Ferry quotes Deleuze stating this as "instead of the unity of an active life and an affirmative thought, one sees thought take on the task of evaluating life, of contrasting it to values claimed to be superior and judging it by those values, of limiting it, of condemning it. In so doing, thought turns negative, we see life depreciated, ceasing to be active, reducing itself to its weakest forms, morbid forms compatible only with the so-called superior values." However, Ferry also points out that basing our philosophy on what is human does not have to mean that we reject any form of transcendence, if by transcendence we understand "immanent, not created by reason" rather than "an external agency". Kant introduced "transcendental" in the sense of "a priori", something not produced by our senses, but which allows us to perceive objects as objects, and there is no reason why there would not also be something "hard wired" into our brains that would influence how we form value judgements. In contradistinction to materialism, where values are produced by humans, values, or the basis for making value judgements, are in the human and have to be discovered. Ferry call this "horizontal transcendence" rather than "vertical transcendence"; that is, it is focused on fellow humans rather than on a deity, and he gives good arguments for why this appears to be so, and that this is indeed a central component of what it means to be human. In the view of evolution and the role of the individual put forward in this monograph, the "horizontal transcendence" is the essences of intelligence; it is why we have ended up as what we are today instead of as something else. And it is what will continue to guide evolution, if only we do not restrict its operation.

Accepting this generally as our philosophical framework, it is located within that branch of philosophy identified as secular humanism. And from our identification of human intelligence as the driving force behind the evolution of society, we are led to accepting the extent to which individuals are able to exercise their intelligence as an important measure of the process of evolution. However, referring to the simple model of intelligence shown in Fig. 3.1, and the definition of intelligence as goal-oriented adaptive behaviour, this model illustrates *how* intelligence operates, but *why* does it operate? What is it that *drives* the process? The finest intelligence in the world has no effect on the evolution of society if it is not used to generate adaptive actions. The force that drives the process is *will*. Our sensors may perceive changes to our environment, but to then engage the processes and convert that input into adaptive behaviour requires an effort, an exertion of will-power. We could incorporate this in our simple model by inserting the will as a gate between the sensors and the processing facility, as shown in Fig. 3.2. Will is the force driving evolution; intelligence is the process steering evolution. They are two sides of the same coin; what we called "life". Or, in a similar vein, as Hannah Arendt said: "Will is our mental organ for the future, just as memory is our mental organ for the past".

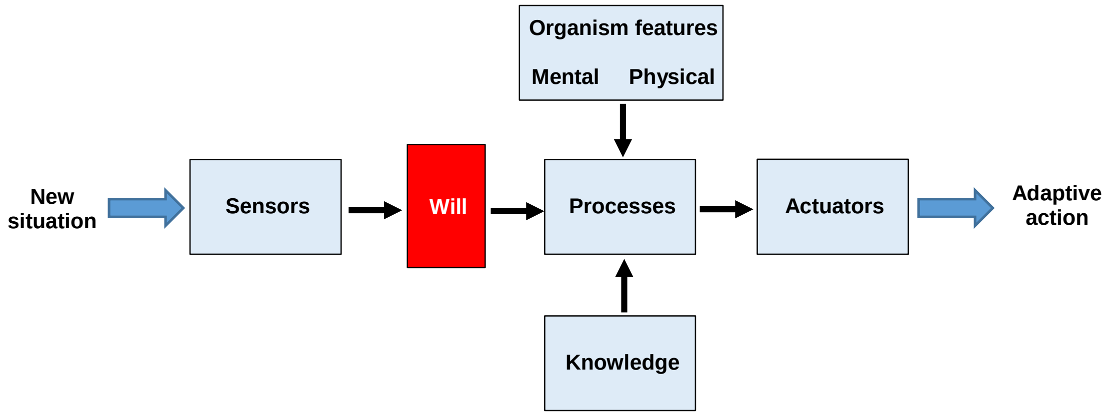

Figure 3.2 High-level model combining intelligence and will.

The concept of will, and its central role in human existence is, of course, not new, and was put forward most forcefully by Schopenhauer in his work *The World as Will and Representation*. In Book ii he describes the will to live as the blind impulse towards existence that is present in all things, and that uses knowledge for its purpose, much as in our model in Fig. 3.2. But, maybe due to his pessimistic and melancholic disposition, he saw this will as condemning man to an unhappy, restless striving to fulfil base desires, and thought that escape from it was only possible by withdrawing from life into asceticism and meditation. That is not the view put forward here; as already noted, the development over the last several centuries has certainly been positive with regard to allowing humans to realise their potential, and the view presented of Nietzsche's philosophy is also basically positive.

In earlier times, the will to exercise intelligence (or capability), such as it were, was very directly challenged by conditions of existence, such as the need for finding food, providing shelter, engaging in person-to-person competition, and so on. Today, the challenges are much subtler and more concealed; the necessity to exercise intelligence (i.e. use willpower) is no less urgent, but it is not about food and shelter, but about the form of our society. Under this perspective, will becomes almost synonymous with virtue, as pointed out by Ellul, a philosopher who otherwise has been highly critical of the influence of technology.

A corollary to this is that the goal of the "goal-seeking adaptive behaviour" can be formulated as allowing unrestricted exercise of our intelligence, reflecting the realisation that it is our intelligence that determines the path of evolution. That is, the "free" in "free will" refers to the absence of external constraining conditions, and the adaptive action is such as to reduce these constraints. It is futile to ask what the ultimate destination of evolution is; we are not evolving towards something, some ideal state here or in Heaven. Evolution is an eternal process of survival. And it does not matter; what is important is that we know what the direction of evolution should be right now. In this sense, it is a differential definition of "the good life".

Fluctuations and risk

If intelligence is something common to all individuals, why does the development of society not progress in a smooth trajectory of continued improvement? Why do we see fluctuations of varying magnitude, in the form of dictatorships, wars, and other atrocities? The main part of the answer to these questions is that while the processing ability is more or less the same in every human, the knowledge and data on which the processes act differ considerably for each individual. As we saw earlier, this data can be divided into two parts; that provided through formal education and that absorbed from society through various channels, and both of these vary from person to person. So, while both intelligence and will are characteristics of individuals, and while the criterion on which the adaptive action is selected is the same for all individuals, the assessment of what is the appropriate action to meet that criterion in a particular new situation will depend on the knowledge available to the individual.

The smaller part of the answer lies in the fact that the inherited (endosomatic) components of intelligence, i.e. the mental features, the processing capacity itself, and the will, as shown in Fig. 3.2, also vary somewhat on an individual basis, but these variations are much less significant in the context of fluctuations, as the following argument shows. If we could observe the adaptive actions of a large collection of isolated individuals to a given new situation, we would find a distribution of actions, centred around some mean. However, in a society the individuals are not isolated, but interact more or less closely. The adaptive action of one individual creates the new situation for other individuals, resulting in a feed-back mechanism and a *dynamic behaviour* of the collection of individuals that can display large local fluctuations from the mean. And this feed-back operates via the knowledge base only.

Two factors are particularly important in driving fluctuations: the intensity and speed of the interaction, and the means available to small groups to support large deviations from the mean. The former has increased by orders of magnitude over the last few decades through such means as mobile phone, internet, and social media; the latter arise from the abundance of, and easy access to, increasingly sophisticated means for controlling the dissemination of information (including its suppression) and for armed suppression of dissent (conventional, biological, cyber, and nuclear). On the other hand, the generation of knowledge and its dissemination through education, and also informally through the same media that support interaction, have increased greatly, and so, from this point of view, it appears that the future will be a race between the knowledge and understanding of what benefits life (for the global society), and the ability to enforce a local deviation from that understanding. The worst outcome of that race would be such a large fluctuation from the average path of evolution that the whole system becomes unstable and collapses.

To recapitulate, then: Under this perspective “the good life” is a life that supports and promotes a development that enables the free exercise of intelligence. It is, in this sense, a differential definition of “the good life”, recognising the dynamic nature of society. But it is, perhaps, the manner in which the issues accompanying the development of society are dealt with that is most controversial, and as in all matters whose consequences lie in the future, there is the concept of *risk*. That is most easily illustrated when it is applied directly to one of the technologies driving the evolution of our society, such as nuclear power or genetic engineering, but there is a much subtler, underlying issue: Consider humanity on a global scale, structured into regions, nations, communities, organisations, families, and individuals; all interconnected and forming an extremely complex system. This system is evolving, not slowly and as a result of adaption to a changing environment, as was the case in the past, but with increasing rapidity and as a result of human will. In driving that evolution, there might be a broad consensus regarding the aims, i.e. to give humans a better life in the form of health, peace, justice, self-fulfilment, and so on, but in applying our intellectual power to achieve this, there is a risk that we might be getting it wrong. So, instead of focusing on what we want to achieve, should we balance the application of our intellectual power more evenly between product and process, so as to minimise the risk to the evolution of our society? Heidegger was concerned that the object of engineering was the intensification of means, without considering ends, leading to development for its own sake. That is not really correct; the desired ends are reasonably clear, and the proliferation of means available for consideration to achieve them can only be good; it is the choice of process that is the issue. And, in particular, the risks involved in the process; do we understand them, and are we employing our best resources in order to minimise them?

The issue of risk is also raised by Ferry in the last chapter of his book in relation to the concept of a “second modernity”, and he refers to the book by Ulrich Beck, where this issue was brought to public attention a couple of decades ago. In that book, the hazards leading to risk are seen as being predominantly related to technology, such as nuclear energy and the industrial contamination of water, air, and foodstuff. But Beck also states "Risk must be seen in a social setting. While technology may be the most obvious cause, the risks are created and effected in social systems; the magnitude of the physical risk is a function of the quality of the social relations and processes; and the primary risk is therefore the social dependency on institutions and actors that may be alien, obscure, and inaccessible to most people affected by the risks in question.", and with a small amount of interpretation, this expresses the risk associated with the process of applying and developing technology. After considering the ethics involved in applying technology, we shall return to the issue of risk when we propose a possible approach to controlling the application of technology.

Ethics

Ethics, as the branch of philosophy that involves systematising, defending, and recommending concepts of right and wrong conduct (from Internet Encyclopedia of Philosophy) has been, and continues to be, a central theme in the literature around the application of technology and its influence on the individual and society. And the foregoing considerations about a measure of evolution do, of course, contain a very definite statement about ethics, in that the introduction of a particular application of technology is right or wrong according to whether it increases our ability to exercise our intelligence or not. In the area of research identified as Philosophy of Technology, ethical issues related to how technology is developed and introduced; that is, related to engineering, either explicitly or implicitly, have seen considerable activity from both philosophers and engineers, as evidenced by some recent publications listed in References at the end of this monograph. The issues have been mainly concerned with the behaviour of individual engineers towards other individuals as well as their environments, as exemplified by numerous Codes of Ethics. These form a set of *rules* that define engineering as a practice; they form a framework that restricts *how* engineering is to be performed, but say nothing about the *value* of the engineering or, in our case, about to what extent the technology application advances society in a desirable direction. That issue was addressed by the author in a recent publication, no. 5 in References, in connection with the particular responsibility of engineers to provide society with the information required to make a decision about value. What we are confronted with now, are the ethical issues involved in controlling the introduction of applications of technology; a responsibility that can, in the final analysis, only be carried by society as a whole.

We previously mentioned the work of Heidegger. He considered technology not principally as objects and methods, but as an *a priori* framework for control and manipulation; as a feature of our nature and of our relationship to Nature. He called this transcendental precondition of technology "Ge-stell"; it is our technological attitude toward the world that sees Nature both as a challenge and as a resource to be exploited, and he was concerned about its realisation as a kind of reified dogmatism in recent times. Implicit in this view is that, despite this deep connection, humans and technology (in our sense) are separate entities, that our human values should be able to remain unaffected by technology (but his gloomy view was that they would probably not). That is, the influence of technology is seen as corrupting the free individual, but to this we would say that the concept of a "free" individual is in any case an illusion; individuals in today's society is no more "free" than cells in our bodies, and technology has a similar relationship to society as chemistry has to the body. In the more recent work on the relationship between humans and technology, as exemplified by Don Ihde and Bruno Latour, it is accepted that the relationship is so close that there is no clear cut distinction between them; human existence is always influenced by technology, humans are always hybrids, as we mentioned earlier, and we say that our behaviour is *mediated* by technology. However, this loss of human sovereignty poses a problem for ethics; how can we make decisions about the value of technology when technology is already an intrinsic part of the decision-making process? A readable and valuable contribution towards resolving this problem is an article by Steven Dorrestijn, in which he analyses the work of Michel Foucault. We quote:

> "The result is a contribution to an ethics of technology inspired by Foucault's proposal for a contemporary aesthetics of existence. In this ethical perspective, technical mediation and hybridization are not seen as opposing what is genuinely human, but as the very material of ethical activity and reflection. The motivation for this ethic is not absolute law, but a will to give style to the way one is transformed through engagement with new technologies. The practical efforts and skills needed to accommodate and integrate technologies into our modes of existence become a pivotal aspect of ethics. As an alternative to mere resistance against intruding powers, this approach explores the active form-giving activities of subjects with respect to their hybrid mode of being. The aim of this ethics of technology is to establish interactions and fusions with technologies in such a way that they are experienced as one's own, not obstructing but becoming part of one's experience and performance of freedom and agency."

This view of ethics in relation to technology resonates strongly with the view presented in this monograph; "one's experience and performance of freedom and agency" is very close to "the unrestricted exercise of intelligence". It is probably a disappointing view to anyone looking for a definition in terms of an absolute law or immutable principle, but it reflects the reality of evolution, the fact that we, as hybrids, have a dynamic nature that evolves as we establish "interactions and fusions" with new technology. It does not invalidate the rule of "do to others as you wish others to do to you", it is just that what we wish others to do to us evolves.

In transforming this view into practical action, the ethical aspect becomes a question of how we ensure that the application of new technology becomes part of one's experience and performance of freedom and agency, or equivalently, how the application of new technology is controlled by exercising the intelligence of the members of society where the technology is to be introduced. A corollary to this question is that the *value* of new technology is measured by the extent to which it enables the unrestricted exercise of intelligence. The next section considers this question, and details a possible approach in order to illustrate some of the issues involved.

Before leaving this very brief excursion into ethical aspects of technology and its development, we should point to some recent work that is very relevant to the view of ethics as a product of evolution put forward here. In his book, *The Ethical Project*, Philip Kitcher argues convincingly for a view of ethics as a product of human effort since the dawn of our species – an effort to avoid the propagation of altruism failures. Ethics emerges as a human phenomenon, permanently unfinished, a project in which we have been engaged since our early ancestors *invented* ethics. Under the umbrella of *pragmatic naturalism* – an umbrella that also covers the view of evolution put forward in this monograph – Kitcher provides a view of how ethics could have developed; a view both reflecting historical facts and appealing to nothing but common sense. It not only provides a story of how ethics evolved as a sequence of progressive changes, but is also able to answer questions about truth and authority that could be raised about the validity of this view.

There is considerable similarity between Kitcher's view of ethics and its development and our view of the evolution of society. Central to his position is the assertion of man's inherent disposition towards altruism; a disposition that develops form biological altruism (foregoing reproductive success in favour of that of others) through behavioural altruism (foregoing the fulfilment of own desires on order to promote the perceived wishes of others) to psychological altruism (acting without self-interest for the perceived good of others). This successive increase in what might be thought of as the "purity" of altruism parallels the evolution of intelligence as the increasing predominance of knowledge over instinct; the difference being that instead of a disposition toward altruism we are assuming a disposition toward survival, and what Kitcher identifies as altruism failures we identify as information failures. The question that this comparison raises is whether there is any necessity for assuming an inherent predisposition to altruism, or whether this predisposition emerges in the search for survival strategies as society develops.

Controlling technology

As we discussed in both of the preceding chapters, technology and its applications have a very significant influence on the evolution of society, and this influence is increasing. So, if we, as the individuals making up society, are to be able to exercise our intelligence by taking goal-oriented adaptive actions, we need to be able to control that influence, and that immediately raises two issues. One, in order to control something, we need to be able to measure it. The influence of technology can be seen in many aspects of society, ranging from economic measures, such as GDP or income distribution, to such less exactly defined measures as the quality of our environment, but based on the view of evolution we developed earlier, a central measure is the extent to which we are able to exercise our intelligence. The importance of this measure is not only in its global character (it can be applied to any application of technology, although the value of the measure might in some cases be zero), but also in that it is in itself the means of control. That is, there is a positive feed-back, in that if technology is applied that increases the restraints on our ability to exercise intelligence, then next time we are required to exercise control we will be even less able to do so, and so on, and this is why some observers believe we are losing control of technology.

Such a pessimistic view of the future is not consistent with our story. The fundamental premise of our story is that, in the long run, it is individual intelligence and its exercise through the application of will, averaged over all members of society, that determines the evolution of society, and that, based on past experience, the direction of this evolution is good. Consequently, at any point in time, the measure of acceptance of a new application of technology should be the extent to which it supports and promotes that development by enabling the exercise of our intelligence, and for convenience, let us label that measure by X. That extent is a function of two variables: one a characteristic of the individual – the individual's inherent willpower – and the other the restraining circumstances in which the individual finds itself. If there are no restraining circumstances, X takes on its maximum value, irrespective of the willpower of the individual. That is, if there are no restraining circumstances, no willpower is required to exercise the intelligence; willpower is needed only to overcome restraining circumstances.

Extending our story into the future therefore requires us to propose a procedure for controlling the influence of technology on society. From the above it must be one of estimating the current value of X for the groups of society that would be affected by a particular application of technology presented to society and also estimating the change in X that would result from the introduction of the application. The control action is then, basically, to reject the application if the value of X decreases, and accept the application if it increases. But in many cases there is not only a single run through this basic procedure. If the application is at first rejected, its proponents might modify it to make its impact more favourable and put it forward again, and a particular application could go through this loop several times.

It is important to emphasize that what we want to control are *applications* of technology; we do not want to control the development of technology itself. The development of the knowledge and resource bases that constitute technology can only be beneficial, and, indeed, it is this technology that provides the basis for our evaluation.

Before going any further with describing the control procedure, we need to point out, or remind ourselves, as the case might be, of some features of such a procedure that are already visible. Firstly, the impact of a technology application on society may depend not only of it passing through the control process, but on its *acceptance* by its intended users or consumers. Evaluation and acceptance are two different processes; the first is an expectation, the second reality. There are at least three obvious reasons for why they are different: One, reality is so complex and involves so many factors that no practical evaluation model can account for them all. Two, even if evaluation could account for all the known effects of an application, there is always the possibility of unintended consequences. And three, the two are separated in time; acceptance may be realised years after the evaluation, during which time unforeseeable changes may occur, such as the appearance of a competing application.

Secondly, our evaluation considers only a single criterion – the free exercise of intelligence. This has been put forward as the single, most significant characteristic of the type of society we desire, or “the good life”; in the short run many other criteria can be important. For example, environmental impact may be the most important and immediate criterion at the time of introduction of a new application, but, in the long run, the effects of the decision will be reflected in its impact on “the good life”. This means that our evaluation requires a “translation” from special interest concerns to their impact on the free exercise of intelligence, which will have its own problems, but it also means that our evaluation is independent of any ideology (except the belief in humanity).

Thirdly, many applications of technology will have no discernible impact on the evolution of society, as we have defined it. Their acceptance or otherwise will be based on other criteria, mostly of an economic nature, but also aesthetic or environmental, or anchored in any number of irrational beliefs.

The first step in the control procedure is the identification and characterisation of what constitutes the “society” in the particular case, and the structure of this society as a system of elements, in the form of organisations and groups of people. Our measure of evolution is defined as an average so we must identify groups of people that exist in similar circumstances and that will be affected by the particular application of technology in the same way, and take the average over the members within a group as representative for the group. For the particular society, the measure of evolution is then taken to be the weighted average over the groups, with the weighting being determined by the number of individuals in each group.

The next step in the procedure is to determine the current value of X for each group in the society of interest, and then form the average. For this to be possible, the data entering into the definition of X must itself be both available and well defined, and it must be possible to assign it to the chosen grouping. In practice, this means choosing a *evaluation model* of X in terms of willpower and restraint on the ability to exercise intelligence in terms of parameters that are both significant and for which data is available. Starting with the restraint, there are many possibilities, both as regards the number of restraints and the definition of each restraint. The following proposal is just one such possibility:

a. A significant factor is clearly the financial situation in which the individual finds itself, as measured by income per person per year, q. If the *subsistence level* at the location where the individual lives is denoted by s (\$/year), the *financial restraint*, r_1, is defined to be of the form

$$r_1 = e^{-\frac{q-s}{q_a}} \tag{3.1}$$

where $q \geq s$, $r_1(q < s) = 1$, and q_a is the income averaged over all the members of the society. The interpretation of this restraint is that at (or below) the subsistence level the individual has essentially no time or energy to exercise intelligence; all effort is absorbed by mere existence. Nor is there any surplus income for acquiring information. As the income rises above the subsistence level, the restraint is reduced, but the reduction depends not directly on the value of this increase above the subsistence level, but on the relationship of this value to the average income in the society. If this is the most appropriate measure of the effect of increasing the income above the subsistence level is open to discussion; the choice in Eq. 3.1 is somewhat arbitrary.

b. The access to and level of education is a prerequisite for obtaining and evaluating information, and thereby generating the knowledge which forms such an important part of exercising intelligence. As the exercising of intelligence we are considering relates to the evaluation of technology applications for their impact on the evolution of society, the knowledge required is of a general rather than of a detailed nature (such as is required for creating technology). Consequently, the lower levels of education are more important; literacy is very much more important than having a PhD. We might therefore propose to evaluate the *attained educational level* as 0.6 for primary education, 0.9 for secondary education, and 1.0 for tertiary education, and define the *educational restraint*, r_2, as

$$r_2 = 1 - \textit{attained educational level} \qquad (3.2)$$

c. Having both the time and the education to process information into knowledge still leaves the issue of being able to obtain the information. That ability can be considered to consist of two separate factors: One, *access* to the media carrying information (printed matter, radio, television, internet, social media) via such channels as newsagents, public libraries, broadband, and mobile phone. Two, the *quality* of the media, reflected in the level of censorship, diversity, ownership and control, accuracy and completeness of the information, and so on. Evaluating access on a scale of 0 – 1, with the value 1 signifying full access to all existing information channels, as would be the case in many parts of the developed world. Similarly, evaluating quality on a scale of 0 – 1, the value 1 signifies the absence of censorship, a vigorous multiplicity of sources, and a high degree of independence. We therefore define an *information restraint*, r_3, as

$$r_3 = 1 - \textit{access} \times \textit{quality}. \qquad (3.3)$$

d. Being able to formulate an adaptive action is one thing; being able to action it is a different matter, and so lack of access to participation in a democratic and political decision process becomes a further restraint. Democratic, in the sense that all involved have the same rights, is not enough; for the outcome of the process to have any effect, it needs to be a political process. That is, a process that is part of the public affairs of a society and of its government. Consequently, if we denote the level of political rights by u, of civil liberties by v, and of democracy by w, all measured on a scale of 0 – 1, we define the *process restraint*, r_4, as follows:

$$r_4 = 1 - (u+v+w)/3 \qquad (3.4)$$

Having chosen and defined four components of the restraint, r, there remains to decide how these four components are to be combined to form r. There are numerous ways to do this, depending partly on what importance one assigns to each component. For example, one might consider that the financial restraint, r_1, is so important that if it goes to zero, the other components are insignificant, and so decide on a combination of the form $r_1(r_2+r_3+r_4)$. The combination proposed in this monograph does not make such a radical distinction, but allows for a certain weighting of the components:

$$r = \frac{c_1 r_1 + c_2 r_2 + c_3 r_3 + c_4 r_4}{c_1 + c_2 + c_3 + c_4}\,. \qquad (3.5)$$

As was discussed earlier, the extent to which persons exercise their intelligence in the form of taking goal-oriented adaptive action depends on both the will (or willpower) of the person and the restraints presented by the society in which the person is embedded. So, what determines a person’s will to overcome or reduce the restraints? We might think of personality traits, such as strength of character, motivation, and the like, but how would we measure them? Interrogating or testing enough individuals in whatever society we are considering in order to get a significant measure of the average would seem a hopeless task. Rather than starting with the individual, a different approach would be to ask: What characteristics of a society reflect the strength of will of its members? However, a difficulty with this approach is that it tends to lead to a blurring between restraints and will, in that restraints are characteristics of the society, whereas will is a characteristic of individuals. Is there a characteristic of society that does not represent a significant restraint, as compared to the four we have identified, but that is a good indication of the average strength of individual will? One such characteristic might be the level of corruption; we would expect that the will to oppose corruption is in some way related to the will to overcome restraints, but corruption is not in itself a significant restraint on exercising intelligence.

Considering will as the means of overcoming constraints, and the level of corruption as a measure of will, leads to a further line of thought. We have said the will is required to overcome restraints, and that in a society where there are no restraints, there is no need for will. This seems to lead to a paradox, in that in a society with small restraints, there is likely to be a low level of corruption and thus there is a strong will for which there is little need, whereas in a society with large restraints there is likely to be a high level of corruption and thus a weak will where it is needed most. However, that has to be seen in the context of this paper, which is the evolution of society. That is, changes to society, and the restraints are restraints on achieving these changes. But a society that has reached the state of development where there are no restraints to change still needs to *maintain* this state, and that requires will. In such a society a rising level of corruption is therefore the early indication of decay and a reduction in will, soon to be followed by increasing restraints.

If the *level of corruption*, *c*, is measured on a scale of 0 to 100 with 100 being very clean and 0 being very corrupt, then the relationship to the will, *w*, will, without any further justification, be taken to be as follows:

$$w = e^{-\frac{100-c}{\sigma}}, \tag{3.6}$$

where σ is a scale factor that can be adjusted as a better understanding of the problem complex emerges through use of the evaluation model.

The third, and by far most difficult and possibly controversial step is then to estimate the change in the data that is expected to result from the introduction of a particular application of technology, and based on that to evaluate the change in X. Estimating the influence of technology on society requires a multi-disciplinary effort; a combination of sociology, philosophy, psychology, anthropology, engineering, and statistics. Getting people with such varied backgrounds and interests to focus on a common task is difficult.

The fourth step is to generate significant and understandable reports of the evaluation, each one aimed at a specific section of the affected part of society and at the format of the public discourse. There then follow three steps that represent the main involvement of the public: the discourse itself and then a decision as to whether the evaluation is acceptable. If not, the process from the estimate of the change will have to be repeated until it is acceptable, at which point the findings need to be presented and promoted to the relevant decision-makers (in government, industry, and international bodies).

This procedure is summarised in Fig. 3.3.

An important feature of the model is that it provides a separation of the steps in which experts take the lead and the steps in which the public has the main role. That separation implies a mutual trust between the two and respect for each other; without that, any effective control of technology is unlikely. It also allows us to make an observation that applies to all the steps in the first part, and which is valid irrespective of any particular choice of measure of the state of society and of evaluation model: Estimating the influence of an application of technology on the evolution of society is a very difficult and problematic undertaking, and always subject to disagreements and controversy. But the difficulty can be at least reduced by recognising the varying degree of uncertainty in, and disagreement about, the different components that make up the assessment process; what we might for the moment call the *quality* of the component. This is, essentially, the converse of what we earlier identified as *risk*.

First of all, there is the definition of what we understand by “the best” society; what we want society to evolve towards. In the present paper the definition is “the society that maximises the ability of its members to exercise their intelligence”, but there can obviously be many other definitions. This definition cannot arise out of any experiment or measurement; it is a matter of *agreement*, of a shared belief among the multidisciplinary group of experts formulating the definition, and the quality of the definition is the extent to which this group represents, and has the confidence of, the members of society.

Secondly, there is the description of how the measure implicit in such a definition can be quantified; that is, what characteristics of the society will represent the measure, how significant are they, how will they be measured, and what will the accuracy of the measurements be. This component can only be developed by professionals, such as sociologists and statisticians, and if it is done properly, the quality of this component, i.e. the uncertainty in the value of the measure, should not be a matter for discussion.

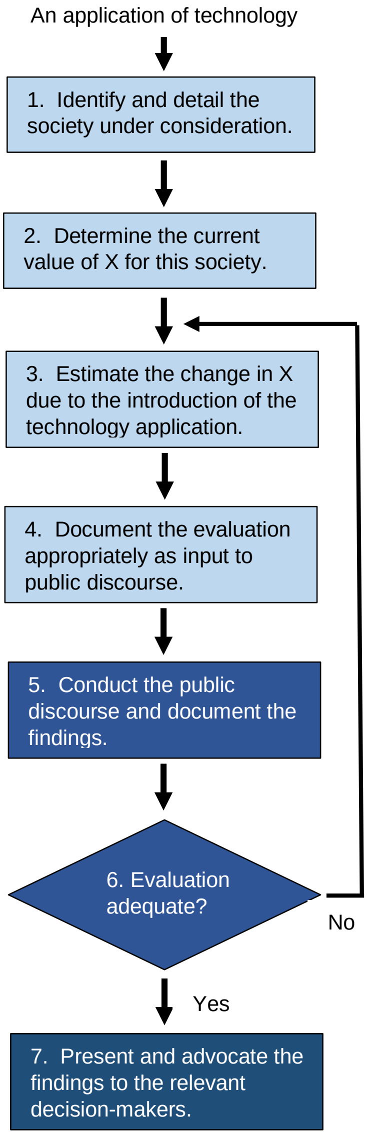

Figure 3.3 The public discourse control procedure. The participation of the public is indicated by the dark shapes and white font.

The third component, the assessment of the impact of technology applications on the evolution of society, presents a very different picture with regard to quality. Again, the work must be performed by professionals working as a group, but the uncertainty inherent in assessing any development into the future results, even among experts, in a range of *opinions*. Each opinion results from a different interpretation of the same data base, and in some cases it will not be possible, nor appropriate, to obtain a consensus or an average opinion; they remain essentially different opinions. The quality of this component is the clarity and honesty with which the outcome is presented; where consensus was reached and where differing opinions persist. It is exactly in these cases of differing opinions that a public discourse becomes relevant.

The fourth component is the documentation and explanation of the work of the experts in terms that are suitable to society as the audience; an audience that might need to be structured. Depending on the application of technology being considered, some sections of society might be more impacted than others, and the documentation may have to be structured to address each of these sections appropriately. The quality of this component is measured by the ensuing public discourse; by its efficiency, not getting bogged down in interminable discussions about irrelevant issues, and by the impact of its outcome.

It is evident that, no matter how high the quality of all the above components is, the interface between the two groups of steps is characterised by what Collins and Evans call ubiquitous judgement. For the society, the crucial judgement is to know when the mainstream community of experts has reached a level of consensus that, for all practical purposes, cannot be gainsaid in spite of the determined opposition of a group of experienced experts who know far more about the science than the general public making the judgement. In our case, we might modify this slightly to say that the crucial judgement is that the group of experts that carried out the assessment really does represent the mainstream community of experts.

In the following subsections we shall consider each of the steps in Fig. 3 in more detail, and identify issues and problems that might arise in executing them.

a. The Society:

As already mentioned, it is of crucial importance to define what constitutes the *society* in each particular case. In principle, and with reference to the butterfly effect, it is always the whole world's population, but in practice we have to draw a boundary around those groups of people that will be significantly affected by a particular application of technology, and be careful to define what we consider as "significant". For example, in the case where the technology application is to introduce piped water into an isolated village (this case was described by Sclove), besides the village inhabitants - what we might think of as the *target* society - there are many other groups of people that are also affected by the application, such as the manufacturers of the pipe, the workers in the factory manufacturing the pipe, the wider society that will forego another investment in favour of this one, the contractor carrying out the installation work, the engineers designing the system, the plumbers that will provide the ongoing maintenance, and so on. However, to these groups, the application is just one of many making up their normal business, and so while the application will have a small impact on such business parameters as turnover, profitability, and the like, the effect on our measure of evolution will be what we might characterise as a *second-order* effect. But there may be groups besides the target society on which the impact is significant; for example, if it is a matter of allocation resources to one application or another, or to apply the same technology to the target society or another group, in which case the impact on the other group is significant.

However, our example of the village raises another issue regarding the definition of the target society. The introduction of piped water will reduce the social cohesion of the village by eliminating the need for women to meet at the well on a daily basis, but this reduction in local focus, together with the outward interaction resulting from being part of a municipal water supply scheme will make the inhabitants more active members of a larger society. The change resulting from this application of technology is not only a change to whatever parameters characterise the village, but to the structure of the larger society in which the village is embedded. That is, simply enlarging the target society and applying the same parameters to it would have no effect. We have to introduce a parameter that measures the integration of the village in the larger society; a parameter that is largely irrelevant to the isolated village.

The point is that defining the society, as in the sentence "the impact of the technology application on the evolution of society", requires considerable thought and effort. On the one hand, it is easy to overlook one or more groups of people that will be significantly affected, simply because the manner in which they are affected is quite different to the one that applies to the target society. On the other hand, including second-order effects will complicate the evaluation and lead to interminable discussions about matters that have no effect on the evolution of society.

b. Determine the current value of X:

Recall that X is defined as the extent to which a member of society is able to exercise his or her intelligence, averaged over all members of society, and that this extent can be expressed in terms of the restraints limiting it and the will (or motivation) to overcome these restraints, typically in the form shown in Eq. 3.1. A choice of these parameters, and the manner in which they combine in order to determine X, was detailed above, but irrespective of the particular choice, it is imperative that data is available that can determine the values of the parameters in a credible manner. It is one thing to have an agreed conceptual understanding of a parameter, but quite something else to agree on how it should be measured and on the validity and accuracy of measurements undertaken to date. This can be a problem even in the physical sciences, where the measurement and value of a conceptually well-defined parameter might still be subject to discussion, as the discussion about global warming illustrates, but it is much more severe in the social sciences. The measurements often involve sampling, which gives rise to controversy about the appropriate selection and size of the sample, and the measured values may sometimes be subject to a certain amount of "cleaning" and normalisation.

This is where the knowledge and expertise of the professional is required, and the objective must be to present the data and the argument for its validity in such a manner that it is understandable by the great majority of members of the society, and that the argument is robust enough for any spoiling attempt to be identified as such by this majority. All too often the deliberations about the model of the phenomenon in question get bogged down in unnecessary controversy about the data.

c. Estimate the Change in X:

If obtaining credible data for the present state of a society is difficult, estimating the change to this state due to the introduction of a particular application of technology is considerably more difficult and open to controversy. The main reason for this is that, while estimating the change in value of any parameter characterising a society is encumbered with all the uncertainties of the future, many of these parameters are slowly changing and display a definite trend which allow an extrapolation into the future, whereas introducing a new application of technology is often without any valid precedent. Being new, there is no previous trend.

Some further difficulties are:

a. The effects of the application may develop over a long time period, and as the effects will generally be dependent on the environment in which the application is active, assumptions have to be made about changes to this environment, which introduces a further level of complexity.
b. Besides the intended purpose of the application, there may be unintended consequences, and some account has to be taken of the likelihood and severity of these.
c. The process of generating the effects of an application is generally not a linear one; there may be a "critical mass", or there may be a self-reinforcing feature involved.

The limited literature survey in the section *Technology – a component of society,* in Chapter 2, shows some of the issues and different approaches considered by a number of researchers. It demonstrates the existence of a very significant capability in many of the disciplines required to carry out evaluations of the type envisaged here; an activity that also goes under the name of Technology Assessment (TA). But it is exactly the multidisciplinary nature of the work that makes it difficult to realise; it requires a coordinating and managing authority. This authority would have to be vested in a body that is independent and not influenced by special interests, which indicates that it would have to be a statutory authority. An example of such a body was the Office of Technology Assessment of the US Congress, which was operational in the period

1972 to 1995, and there are currently a number of similar bodies in existence, mainly in Europe, as is described in an article in Wikipedia (http://en.wikipedia.org/wiki/Technology_assessment). This article also highlights the problems with TA; in particular, the problem of impartiality. A statutory government body is often far from impartial, as governments are major players in the introduction of new applications of technology**.**

This is perhaps a suitable point in this monograph to make a comment about the term "technology assessment" and about the relationship between technology and science. We have defined technology as the resource engineers use in creating applications that meet expressed needs. That technology is based, in part, on science, and that science is generally well understood, accepted, and uncontroversial. For example, the technology involved in creating a coal-fired power station is known in every detail and is not a subject of discussion; it is the result of actually operating the power station that is a subject of discussion. (Similarly, it is not nuclear physics that is controversial, but the effects of actually building and dropping the bomb.) In TA, it is not the technology that is being assessed, it is the effects of applying the technology that is being assessed, and the aspects of the science that goes into that assessment that may be controversial, as the assessment of the effects of generating CO_2 illustrates.

This needs to be kept in mind if we group applications of technology according to whether their effects are problematic or unproblematic. It is not the technology that is problematic or unproblematic, it is the effects of a particular application of technology that may be characterised in these terms. And this may often be correlated with whether the science involved in assessing the effects is disputed or undisputed, as discussed by Collins and Evans.

However, the fact that technology assessment is difficult does not mean that it is not both important and necessary, particularly in view of the increasing presence of technology in society; technology is a major component of our culture. One approach that might reduce the difficulty somewhat is to recognise general trends in the evolution of society, such as population shifts, level of education, life expectancy, economic activity, and globalisation, but also the increasing influence of technology in general, and then consider the impact of a particular application of technology on this background. That is, the impact is treated as a *perturbation* on a steadily evolving background. Of course, this shifts some of the difficulty and uncertainty onto developing such an agreed view of the future, but it would have to be done only once and then reused many times within the validity period of the view, rather than starting from scratch in each assessment of a technology application. And because the parameters of the evaluation model must be included in the set of parameters describing the view, it follows that these parameters can only be relatively slowly changing ones. The evaluation model cannot take into account any impact on parameters that are rapidly fluctuating due to other causes.

Such a view represents a *dynamic model* of society, but its multidisciplinary nature makes it quite different to some of the models used by individual disciplines. For example, sociologists might speak of Lenski's model of the development of society or of the simple model of C. Wright Mills, economists might refer to the IMF Global Economic Model, and so on, but because the model we are considering would look at a characteristic of society (i.e. the quantity X) that does not fall into any one discipline, its development would need the cooperation of several disciplines. Again, this is something that is difficult to achieve.

d. Documenting and disseminating the evaluation:

The first thing to note with regard to documenting and disseminating the results of the expert assessment is that it represents a substantial part of the whole control procedure. In order for the ensuing involvement of the public to be of significant value, this step needs to be carefully planned and executed. It is also a step that can be largely performed by professionals from the discipline of communication, and should consequently be relatively uncontroversial. The only exception is the first activity in this step, which is to determine and characterise the audience. The audience is basically the society identified in *a*, but, as was remarked there, this may include millions of people, and just as the evaluation required this mass of people to be structured in a manner that would make the process manageable, the audience needs to be structured in order for the information transmission to be effective.

The issues involved in successful communication are understanding of the cultural background and cognitive capabilities of the recipients and of what is important to them in their current context, as well as developing an efficient and effective means of communication. The importance of using a language that is appropriate to the audience is well known, and there are numerous publications and guidelines that address this issue. And, perhaps most important of all is the *fidelity* of the process; any transformation of the data resulting from the assessment, such as condensation or simplification, must retain the significant results, the *meaning*, of the assessment. Given the domination of public information channels by vested interests, as was already raised earlier; this may be the main obstacle to realising the public control procedure. The implication of this is that the evaluating authority would need to have an independent channel (or channels) to the public, and at least in those societies where there is good access to the Internet, that should not be a problem.

e. The public discourse:

In the current context, the meaning and purpose of public discourse are as a means of society at large to form an opinion on the desirability of introducing a new application of technology. How such a discourse can be realised, how effective it is in reaching a consensus, and to what extent it can influence the decision-making process has been the subject of both empirical and theoretical investigations, as mentioned in Chapter 2. With the developments in information and communications technology (ICT) and social media, the means of conducting such discourse have increased dramatically in the last two decades, but has the impact of public discourse on technology applications really increased in this period? That is not a question that can be answered in this monograph, but we can raise two questions that have a bearing on this, and the first one is: What are the barriers to public discourse?

For an information exchange to qualify as a discourse, it needs to include an interaction between the participants which displays both continuity (a thread) and progress (a direction); if the participants simply post their opinions on a common site, this does not qualify as a discourse. Barriers then become barriers to fulfilling these requirements, and the first such barrier is the short duration of many interactions. For example, the Letters and Opinions sections of daily newspapers provide a forum for public interchange of information, but aside from the fact that only a selection of submissions gets published, there is usually only one response to a posting before attention moves on to more recent news, so there is neither continuity nor progress. The same can be observed on many web sites (e.g. blogs or wikis) where the subject matter wanders all over the place.

A discourse requires a certain discipline, and it requires a willingness of the participants to put in some work in the form of consideration and analysis of the material being put forward in order to display progress. There are, of course, web sites that support valuable discourses, but they are generally not truly public in the sense that they are known to only a small group of people. It is doubtful if a public forum can support a discourse without some form of moderation and control, and so another barrier is to provide such a managed forum without influencing the outcome of the discourse.

The second question is: Is there actually a desire on the part of the majority of society members to participate actively in a control procedure? And if yes, is this a desire that would manifest itself as soon as an opportunity is available, or is it a latent desire that would need education and motivation to become active? Given the often low (unless it is compulsory) voter participation, this is certainly a valid question, and one to which the answer is beyond this paper. One small indication in this regard is the Swiss system of citizens' participation through the referendum process. In the twenty year period 1995 – 2014 there were 172 referendums, of which at most 14, or about 8 %, could be said to relate to applications of technology (http://en.wikipedia.org/wiki/List_of_Swiss_federal_referendums). So, applications of technology are certainly not what is uppermost in peoples' minds, even in such a technologically advanced society as Switzerland.

However, it should be clear that the view of the evolution of society put forward above implies the importance of a public discourse within the control procedure. The alternative is a multitude of separate discourses, each governed (and financed) by a separate interest, and while the competition between these will, in the long run, result in some sort of average outcome, the fluctuations will be much more significant (and costly). This behaviour, which can be described by viewing society as a system of elements, was discussed in Chapter 2, and in an analogy with a thermodynamic system, the stability of society was related to the forces that bind the elements together.

f. The decision:

For the control procedure to progress beyond the public discourse, that discourse must result in a decision that can be presented to the body that makes a formal determination, in the form of a policy or other form of legislation. The decision can basically take one of three forms:

a. The evaluation and/or its documentation is found wanting in part or in its totality, and is returned to the evaluating body for rework;
b. the evaluation allowed the public discourse to result in a majority decision to recommend rejection of the application; or
c. the evaluation allowed the public discourse to result in a majority decision to recommend that the application should proceed.

The concept of "majority" can be controversial in the case of a public discourse. In a few cases, such as noted above for Switzerland, the legislative framework allows for citizens to request a referendum, but otherwise the operational definition of "majority" would have to be contingent on the body managing the control procedure and its means of communication with the members of society.

In the case of our village, a decision would most likely be taken on a show of hands at the final meeting of the public discourse. As in all other places in the world, the introduction of running water would be seen as a benefit and the decision would be positive, but the importance of the whole public process is the resulting sense of ownership and the associated positive attitude which will greatly enhance the beneficial aspects of the application.

g. Implementation:

The last step in the procedure is the incorporation of the decision into the formal implementation process; typically a political policy process. This incorporation can range from a prescribed, mandatory processing of the decision (e.g. into legislation) to a suggestion for consideration, but without any formality or definition of the incorporation, the whole control procedure is unlikely to have a significant impact. Chapter 2 noted some of the work that has been done on the interface between the public and policy makers, but aside from the Swiss example, there does not appear to be any examples of a formal and binding interface. Even in the case of the OTA, as mentioned in Chapter 2, which was a body created by the legislative power, the degree of influence was questionable; enough so that the body was eventually dissolved.

The above procedure and its associated evaluation model form a proposal for a tool for controlling the application of technology. The amount of space devoted to describing this tool reflects the central position we assign to technology in the evolution of society and, correspondingly, the need for effective control. There is nothing unique about this proposal; it is only an example. But for whatever procedure we adopt to be effective, it will need to implement the basic features of this example; that is, independent and trusted professional input to a public decision-making process, and an integration into the political process that guarantees a faithful enforcement of the decision.

Conclusion

The picture we should have of evolution is a succession of *forms*, from simple molecules to complex organisms, as the result of a relentless process of creation and destruction. The details of the process have changed over time, but in the present stage – since the appearance of the genus *homo* – the determining character of this process has changed from the physical to the mental, and from the individual to systems of individuals, or *societies*.

The development in the three chapters of this monograph – the story of us – can be summarised by saying that, throughout the evolution of society, it has been the collective application of that unique human capability we call *intelligence* that has guided this evolution to where we are today. As with every collective process, it has displayed fluctuations, but on the whole it has been a progression towards a richer life in terms of both experience and expression for the average member of society, and so we should put our trust in this capability and let it lead us into the future.

Our simple model of intelligence demonstrates that what is normally thought of as “intelligence” is only one of the components of the ability to take goal-oriented adaptive action; our data processing facility. The most important component as far as evolution of society is concerned is the data base on which the processing facility operates, consisting of knowledge and understanding acquired through education, training, and study, and the flow of information we receive through direct interaction with others and the various media. And so we are led to the conclusion that the most crucial issue in order for intelligence to guide the evolution of society is freedom of information. Conversely, the greatest danger of large fluctuations does no longer take the form of physical repression; wars, uprisings and repressive regimes are now only symptoms associated with the corruption and suppression of information, and the substitution of ideology for truth.

Throughout our story, the development and application of technology was the most prominent and ubiquitous measure of evolution, and we realised that associated with technology were a number of issues that require our urgent attention. The reason for this urgency is itself a feature of technology: its reinforcing power. A level of technological development promotes the development and application of new technology, and so there is a positive feed-back effect that has resulted in a rate of change that has now reached a level where our processes for applying intelligence to the control of technology appear inadequate.

The first issue is the use of technology to suppress symptoms of a problem by force rather than solving the problem itself. This can be observed at all levels of society, from the increased use of surveillance and enforcement technologies to combat crime as a substitute for addressing the motivations for crime, to the investment in advanced weapons technology and increased defence budgets as a substitute for addressing the roots of international disputes. We are seeing technology being used to turn leadership into dominance.

A second issue is the role of technology in changing what it is to be human, in changing how we behave and think, and in transforming the fabric of society itself. There are the numerous obvious manifestations of this in the equipment and systems we use in our daily lives to replace manual tasks, to increase our mobility, and to improve communications and access to information. A less obvious, but not less important consequence of applying technology is that it leads to a shift in the ratio of labour to capital as components of the economy. Increasing the applications of technology requires an increase in investment and a corresponding increase in the capital base of society, which through the return on investment provides further resources for investment. In addition to the impossibility of continuing such a spiralling process indefinitely, it also raises serious concerns regarding such issues as equity and social justice, and makes a rethink of current capitalist ideology a priority.

Given our realisation that it is human intelligence that is guiding the evolution of society, and the fact that the basic processing facility is reasonably evenly distributed over humanity, involving as many of the members of a society in the decision-making process becomes a priority and is the third issue we addressed by proposing a control procedure and discussing some of the initiatives for popular Technical Assessment (pTA). With modern communications technology, involving the whole population should become rapidly more viable.

The fourth issue is then how to ensure that the members of society are provided with the appropriate information for controlling the application of technology. The current trend in concentrated media ownership, the use of the media for advertising and the promotion of special interests, and the shallow and trivial reporting of news have made it increasingly difficult for the public to gain valid and useful information from a media-rich environment. Two options seem to offer themselves to improve this situation: government-funded public broadcasters (radio, TV, Internet) as independent or statutory bodies, and crowd-funded sources, such as Wikipedia.

A final issue is the realisation that evolution is a balance between opposing forces, and that this is a relatively delicately balance. We may think that our unique abilities will always allow us to overcome any problems and survive any fluctuations, but while our abilities are undoubtedly greater than those of any previous species, so are also our means of self-destruction. And present indications are that narrow group interests are gaining relative to those of society as a whole, both on a national and international level, driving our global society further away from an equilibrium state, and while a catastrophic collapse seems a remote possibility, it is not unthinkable, and in a hundred million years the dominant species may look back on us as we look back on the dinosaurs – a sidestep in the march of evolution.

Acknowledgements

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Chapter 2 - Society

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The issue of ethics, with particular consideration of the responsibility of engineers, is also treated in Ref. 5.

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