Chapter 1

Science and Tradition

Man has existed for about a million years. He has possessed writing for about 6,000 years, agriculture somewhat longer, but perhaps not much longer. Science, as a dominant factor in determining the beliefs of educated men, has existed for about 300 years; as a source of economic technique, for about 150 years. In this brief period it has proved itself an incredibly powerful revolutionary force. When we consider how recently it has risen to power, we find ourselves forced to believe that we are at the very beginning of its work in transforming human life. What its future effects will be is a matter of conjecture, but possibly a study of its effects hitherto may make the conjecture a little less hazardous.

The effects of science are of various very different kinds. There are direct intellectual effects: the dispelling of many traditional beliefs, and the adoption of others suggested by the success of scientific method. Then there are effects on technique in industry and war. Then, chiefly as a consequence of new techniques, there are profound changes in social organisation which are gradually bringing about corresponding political changes. Finally, as a result of the new control over the environment which scientific knowledge has conferred, a new philosophy is growing up, involv-

ing a changed conception of man's place in the universe.

I shall deal successively with these aspects of the effects of science on human life. First I shall recount its purely intellectual effect as a solvent of unfounded traditional beliefs, such as witchcraft. Next, I shall consider scientific technique, especially since the industrial revolution. Last, I shall set forth the philosophy which is being suggested by the triumphs of science, and shall contend that this philosophy, if unchecked, may inspire a form of unwisdom from which disastrous consequences may result.

The study of anthropology has made us vividly aware of the mass of unfounded beliefs that influence the lives of uncivilised human beings. Illness is attributed to sorcery, failure of crops to angry gods or malignant demons. Human sacrifice is thought to promote victory in war and the fertility of the soil; eclipses and comets are held to presage disaster. The life of the savage is hemmed in by taboos, and the consequences of infringing a taboo are thought to be frightful.

Some parts of this primitive outlook died out early in the regions in which civilisation began. There are traces of human sacrifice in the Old Testament, for instance in the stories of Jephthah's daughter and of Abraham and Isaac, but by the time the Jews became fully historical they had abandoned the practice. The Greeks abandoned it in about the seventh century BC. But the Carthaginians still practised it during the Punic Wars. The decay of human sacrifice in Mediterranean countries is not attributable to science, but presumably to humanitarian feelings. In other respects, however, science has been the chief agent in dispelling primitive superstitions.

Eclipses were the earliest natural phenomena to escape

from superstition into science. The Babylonians could predict them, though as regards solar eclipses their predictions were not always right. But the priests kept this knowledge to themselves, and used it as a means of increasing their hold over the populace. When the Greeks learned what the Babylonians had to teach, they very quickly arrived at astonishing astronomical discoveries. Thucydides mentions an eclipse of the sun, and says that it occurred at the new moon, which, he goes on to observe, is apparently the only time at which such a phenomenon can occur. The Pythagoreans, very shortly after this time, discovered the correct theory of both solar and lunar eclipses, and inferred that the earth is a sphere from the shape of its shadow on the moon.

Although, for the best minds, eclipses were thus brought within the domain of science, it was a long time before this knowledge was generally accepted. Milton could still speak of times when the sun

> In dim eclipse, disastrous twilight sheds
> On half the nations, and with fear of change
> Perplexes monarchs.

But in Milton this had become only poetic licence.

It was very much longer before comets were brought within the compass of science, indeed the process was completed only by the work of Newton and his friend Halley. Caesar's death was foretold by a comet; as Shakespeare makes Calpurnia say:

> When beggars die, there are no comets seen;
> The heavens themselves blaze forth the death of princes.

The Venerable Bede asserted: 'comets portend revolutions

of kingdoms, pestilence, war, winds, or heat'. John Knox regarded comets as evidence of divine anger, and his followers thought them 'a warning to the King to extirpate the Papists'. Probably Shakespeare still held beliefs of a superstitious kind about comets. It was only when they were found to obey the law of gravitation, and when some at least were found to have calculable orbits, that educated men in general ceased to regard them as portents.

It was in the time of Charles II that scientific rejection of traditional superstitions became common among educated men. Charles II perceived that science could be an ally against the 'fanatics', as those who regretted Cromwell were called. He founded the Royal Society, and made science fashionable. Enlightenment spread gradually downwards from the Court. The House of Commons was as yet by no means as modern in outlook as the King. After the plague and the Great Fire, a House of Commons Committee inquired into the causes of those misfortunes, which were generally attributed to Divine displeasure, though it was not clear to what the displeasure was due. The Committee decided that what most displeased the Lord was the works of Mr Thomas Hobbes. It was decreed that no work of his should be published in England. This measure proved effective: there has never since been a plague or a Great Fire in London. But Charles, who liked Hobbes because Hobbes had taught him mathematics, was annoyed. He, however, was not thought by Parliament to be on intimate terms with Providence.

It was at this time that belief in witchcraft began to be viewed as a superstition. James I was a fanatical persecutor of witches. Shakespeare's *Macbeth* was a piece of government propaganda, and no doubt the witches in that play made it

more acceptable as a piece of flattery of the monarch. Even Bacon pretended to believe in witchcraft, and made no protest when a Parliament of which he was a member passed a law increasing the severity of the punishment of witches. The climax was reached under the Commonwealth, for it was especially Puritans who believed in the power of Satan. It was partly for this reason that Charles II's government, while not yet venturing to deny the possibility of witchcraft, was much less zealous in searching it out than its predecessors had been. The last witchcraft trial in England was in 1664, when Sir Thomas Browne was a witness against the witch. The laws against it gradually fell into abeyance, and were repealed in 1736 – though, as late as 1768, John Wesley continued to support the old superstition. In Scotland the superstition lingered longer: the last conviction was in 1722.

The victory of humanity and common sense in this matter was almost entirely due to the spread of the scientific outlook – not to any definite argument, but to the impossibility of the whole way of thinking that had been natural before the age of rationalism that began in the time of Charles II, partly, it must be confessed, as a revolt against a too rigid moral code.

Scientific medicine had, at first, to combat superstitions similar to those that inspired belief in witchcraft. When Vesalius first practised dissection of corpses, the Church was horrified. He was saved from persecution, for a time, by the Emperor Charles V, who was a valetudinarian, and believed that no other physician could keep him in health. But after the Emperor died, Vesalius was accused of cutting people up before they were dead. He was ordered, as a penance, to go on a pilgrimage to the Holy Land; he was shipwrecked, and died of exposure. In spite of his work and that of Hervey and other

great men, medicine continued to be largely superstitious. Insanity, in particular, was thought to be due to possession by evil spirits, and was therefore treated by subjecting the insane to cruelties which it was hoped the demons would dislike. George III, when mad, was still treated on this principle. The ignorance of the general public continued even longer. An aunt of mine, when her husband quarrelled with the War Office, was afraid that the worry would cause him to develop typhus. It is hardly till the time of Lister and Pasteur that medicine can be said to have become scientific. The diminution of human suffering owing to the advances in medicine is beyond all calculation.

Out of the work of the great men of the seventeenth century a new outlook on the world was developed, and it was this outlook, not specific arguments, which brought about the decay of the belief in portents, witchcraft, demoniacal possession, and so forth. I think there were three ingredients in the scientific outlook of the eighteenth century that were specially important:

'(1) Statements of fact should be based on observation, not on unsupported authority.
(2) The inanimate world is a self-acting self-perpetuating system, in which all changes conform to natural laws.
(3) The earth is not the centre of the universe, and probably Man is not its purpose (if any); moreover, "purpose" is a concept which is scientifically useless.'

These items make up what is called the 'mechanistic outlook', which clergymen denounce. It led to the cessation of persecution and to a generally humane attitude. It is now less

accepted than it was, and persecution has revived. To those who regard its effects as morally pernicious, I commend attention to these facts.

Something must be said about each of the above ingredients of the mechanistic outlook.

(1) *Observation versus Authority:* To modern educated people, it seems obvious that matters of fact are to be ascertained by observation, not by consulting ancient authorities. But this is an entirely modern conception, which hardly existed before the seventeenth century. Aristotle maintained that women have fewer teeth than men; although he was twice married, it never occurred to him to verify this statement by examining his wives' mouths. He said also that children will be healthier if conceived when the wind is in the north. One gathers that the two Mrs Aristotles both had to run out and look at the weathercock every evening before going to bed. He states that a man bitten by a mad dog will not go mad, but any other animal will (*Hist. An.*, 704*a*); that the bite of the shrew-mouse is dangerous to horses, especially if the mouse is pregnant (ibid., 604*b*); that elephants suffering from insomnia can be cured by rubbing their shoulders with salt, olive-oil, and warm water (ibid., 605*a*); and so on and so on. Nevertheless, classical dons, who have never observed any animal except the cat and the dog, continue to praise Aristotle for his fidelity to observation.

The conquest of the East by Alexander caused an immense influx of superstition into the Hellenistic world. This was particularly notable as regards astrology, which almost all later pagans believed in. The Church condemned it, not on scientific grounds, but because it implied subjection to Fate. There is, however, in St Augustine, a scientific argument

against astrology quoted from one of the rare pagan sceptics. The argument is that twins often have very different careers, which they ought not to have if astrology were true.

At the time of the renaissance, belief in astrology became a mark of the free thinker: it must be true, he thought, because the Church condemned it. Free-thinkers were not yet any more scientific than their opponents in the matter of appeal to observable facts.

Most of us still believe many things that in fact have no basis except in the assertions of the ancients. I was always told that ostriches eat nails, and, though I wondered how they found them in the Bush, it did not occur to me to doubt the story. At last I discovered that it comes from Pliny, and has no truth whatever.

Some things are believed because people feel as if they *must* be true, and in such cases an immense weight of evidence is necessary to dispel the belief. Maternal impressions are a case in point. It is supposed that any notable impression on the mother during gestation will affect the offspring. This notion has scriptural warrant: you will remember how Jacob secured speckled kine. If you ask any woman who is not a scientist or an associate of scientists, she will overwhelm you with incidents in proof of the superstition. Why there was Mrs So-and-So, who saw a fox caught in a trap, and sure enough her child was born with a fox's foot. Did you know Mrs So-and-So? No, but my friend Mrs Such-and-Such did. So, if you are persistent, you ask Mrs Such-and-Such, who says: 'Oh, no, *I* didn't know Mrs So-and-So, but Mrs What's-Her-Name did.' You may spend a lifetime in the pursuit of Mrs So-and-So, but you will never catch up with her. She is a myth.

The same situation occurs in regard to the inheritance of acquired characters. There is such a strong impulse to believe in this that biologists have the greatest difficulty in persuading people of the contrary. In Russia they have failed to convince Stalin, and have been compelled to give up being scientific in this matter.

When Galileo's telescope revealed Jupiter's moons, the orthodox refused to look through it, because they knew there could not be such bodies, and therefore the telescope must be deceptive.

Respect for observation as opposed to tradition is difficult and (one might almost say) contrary to human nature. Science insists upon it, and this insistence was the source of the most desperate battles between science and authority. There are still a great many respects in which the lesson has not been learnt. Few people can be convinced that an obnoxious habit – e.g. exhibitionism – cannot be cured by punishment. It is pleasant to punish those who shock us, and we do not like to admit that indulgence in this pleasure is not always socially desirable.

(2) *The autonomy of the physical world:* Perhaps the most powerful solvent of the pre-scientific outlook has been the first law of motion, which the world owes to Galileo, though to some extent he was anticipated by Leonardo da Vinci.

The first law of motion says that a body which is moving will go on moving in the same direction with the same velocity until something stops it. Before Galileo it had been thought that a lifeless body will not move of itself, and if it is in motion it will gradually come to rest. Only living beings, it was thought, could move without help of some external agency. Aristotle thought that the heavenly bodies were pushed by

gods. Here on earth, animals can set themselves in motion and can cause motion in dead matter. There are, it was conceded, certain kinds of motion which are 'natural' to dead matter: earth and water naturally move downwards, air and fire upwards; but beyond these simple 'natural' motions everything depends upon impulsion from the souls of living beings.

So long as this view prevailed, physics as an independent science was impossible, since the physical world was thought to be not causally self-contained. But Galileo and Newton between them proved that all the movements of the planets, and of dead matter on the earth, proceed according to the laws of physics, and once started, will continue indefinitely. There is no need of mind in this process. Newton still thought that a Creator was necessary to get the process going, but that after that He left it to work according to its own laws.

Descartes held that not only dead matter, but the bodies of animals also, are wholly governed by the laws of physics. Probably only theology restrained him from saying the same of human bodies. In the eighteenth century French free thinkers took this further step. In their view, the relation of mind and matter was the antithesis of what Aristotle and the scholastics had supposed. For Aristotle, first causes were always mental, as when an engine driver starts a freight train moving and the impulsion communicates itself from truck to truck. Eighteenth-century materialists, on the contrary, considered all causes material, and thought of mental occurrences as inoperative by-products.

(3) *The dethronement of 'purpose':* Aristotle maintained that causes are of four kinds; modern science admits only one of the four. Two of Aristotle's four need not concern us; the two that do concern us are the 'efficient' and the 'final' cause.

The 'efficient' cause is what we should call simply 'the cause'; the 'final' cause is the purpose. In human affairs this distinction has validity. Suppose you find a restaurant at the top of a mountain. The 'efficient' cause is the carrying up of the materials and the arranging of them in the pattern of a house. The 'final' cause is to satisfy the hunger and thirst of tourists. In human affairs, the question 'why?' is more naturally answered, as a rule, by assigning the final cause than by setting out the efficient cause. If you ask 'why is there a restaurant here?' the natural answer is 'because many hungry and thirsty people come this way'. But the answer by final cause is only appropriate where human volitions are involved. If you ask 'why do many people die of cancer?' you will get no clear answer, but the answer you want is one assigning the efficient cause.

This ambiguity in the word 'why' led Aristotle to his distinction of efficient and final causes. He thought – and many people still think – that both kinds are to be found everywhere: whatever exists may be explained, on the one hand, by the antecedent events that have produced it, and, on the other hand, by the purpose that it serves. But although it is still open to the philosopher or theologian to hold that everything has a 'purpose', it has been found that 'purpose' is not a useful concept when we are in search of scientific laws. We are told in the Bible that the moon was made to give light by night. But men of science, however pious, do not regard this as a scientific explanation of the origin of the moon. Or, to revert to the question about cancer, a man of science may believe, in his private capacity, that cancer is sent as a punishment for our sins, but *qua* man of science he must ignore this point of view. We know of 'purpose' in human affairs, and we

may suppose that there are cosmic purposes, but in science it is the past that determines the future, not the future the past. 'Final' causes, therefore, do not occur in the scientific account of the world.

In this connection Darwin's work was decisive. What Galileo and Newton had done for astronomy, Darwin did for biology. The adaptations of animals and plants to their environments were a favourite theme of pious naturalists in the eighteenth and early nineteenth centuries. These adaptations were explained by the Divine Purpose. It is true that the explanation was sometimes a little odd. If rabbits were theologians, they might think the exquisite adaptation of weasels to the killing of rabbits hardly a matter for thankfulness. And there was a conspiracy of silence about the tapeworm. Nevertheless, it was difficult, before Darwin, to explain the adaptation of living things to their environment otherwise than by means of the Creator's purposes.

It was not the fact of evolution, but the Darwinian mechanism of the struggle for existence and the survival of the fittest, that made it possible to explain adaptation without bringing in 'purpose'. Random variation and *natural* selection use only *efficient* causes. This is why many men who accept the general fact of evolution do not accept Darwin's view as to how it comes about. Samuel Butler, Bergson, Shaw, and Lysenko will not accept the dethronement of purpose – though in the case of Lysenko it is not God's purpose, but Stalin's, that governs heredity in winter wheat.

(4) *Man's place in the universe:* The effect of science upon our view of man's place in the universe has been of two opposite kinds; it has at once degraded and exalted him. It has degraded him from the standpoint of contemplation, and

exalted him from that of action. The latter effect has gradually come to outweigh the former, but both have been important. I will begin with the contemplative effect.

To get this effect with its full impact, you should read simultaneously Dante's *Divine Comedy* and Hubble on the *Realm of the Nebulae* – in each case with active imagination and with full receptiveness to the cosmos that they portray. In Dante, the earth is the centre of the universe; there are ten concentric spheres, all revolving about the earth; the wicked, after death, are punished at the centre of the earth; the comparatively virtuous are purged on the Mount of Purgatory at the antipodes of Jerusalem; the good, when purged, enjoy eternal bliss in one or other of the spheres, according to the degree of their merit. The universe is tidy and small: Dante visits all the spheres in the course of twenty-four hours. Everything is contrived in relation to man: to punish sin and reward virtue. There are no mysteries, no abysses, no secrets; the whole thing is like a child's doll's house, with people as the dolls. But although the people were dolls they were important because they interested the Owner of the doll's house.

The modern universe is a very different sort of place. Since the victory of the Copernican system we have known that the earth is not the centre of the universe. For a time the sun replaced it, but then it turned out that the sun is by no means a monarch among stars, in fact, is scarcely even middle class. There is an incredible amount of empty space in the universe. The distance from the sun to the nearest star is about 4.2 light years, or 25×10^{12} miles. This is in spite of the fact that we live in an exceptionally crowded part of the universe, namely the Milky Way, which is an assemblage of about 300,000 million stars. This assemblage is one of an immense number

of similar assemblages; about 30 million are known, but presumably better telescopes would show more. The average distance from one assemblage to the next is about 2 million light years. But apparently they still feel they haven't elbow room, for they are all hurrying away from each other; some are moving away from us at the rate of 14,000 miles a second or more. The most distant of them so far observed are believed to be at a distance from us of about 500 million light years, so that what we see is what they were 500 million years ago. And as to mass: the sun weighs about 2×10^{27} tons, the Milky Way about 160,000 million times as much as the sun, and is one of a collection of galaxies of which about 30 million are known. It is not easy to maintain a belief in one's own cosmic importance in view of such overwhelming statistics.

So much for the contemplative aspect of man's place in a scientific cosmos. I come now to the practical aspect.

To the practical man, the nebulae are a matter of indifference. He can understand astronomers thinking about them, because they are paid to, but there is no reason why *he* should worry about anything so unimportant. What matters to him about the world is what he can make of it. And scientific man can make vastly more of the world than unscientific man could.

In the pre-scientific world, power was God's. There was not much that man could do even in the most favourable circumstances, and the circumstances were liable to become unfavourable if men incurred the divine displeasure. This showed itself in earthquakes, pestilences, famines, and defeats in war. Since such events were frequent, it was obviously very easy to incur divine displeasure. Judging by the analogy of earthly monarchs, men decided that the thing most displeasing to the Deity is a lack of humility. If you wished to slip through life without disaster, you must be meek; you must be aware of your defencelessness, and constantly ready to confess it. But the God before whom you humbled yourself was conceived in the likeness of man, so that the universe seemed human and warm and cosy, like home if you are the youngest of a large family, painful at times, but never alien and incomprehensible.

In the scientific world, all this is different. It is not by prayer and humility that you cause things to go as you wish, but by acquiring a knowledge of natural laws. The power you acquire in this way is much greater and much more reliable than that formerly supposed to be acquired by prayer, because you never could tell whether your prayer would be favourably heard in heaven. The power of prayer, moreover, had recognised limits; it would have been impious to ask too much. But the power of science has no known limits. We were told that faith could remove mountains, but no one believed it; we are now told that the atomic bomb can remove mountains, and everyone believes it.

It is true that if we ever did stop to think about the cosmos we might find it uncomfortable The sun may grow cold or blow up; the earth may lose its atmosphere and become uninhabitable. Life is a brief, small, and transitory phenomenon in an obscure corner, not at all the sort of thing that one would make a fuss about if one were not personally concerned. But it is monkish and futile – so scientific man will say – to dwell on such cold and unpractical thoughts. Let us get on with the job of fertilising the desert, melting Arctic ice, and killing each other with perpetually improving technique. Some of our activities will do good, some harm, but all alike will show our

power. And so, in this godless universe, we shall become gods.

Darwinism has had many effects upon man's outlook on life and the world, in addition to the extrusion of purpose of which I have already spoken. The absence of any sharp line between men and apes is very awkward for theology. When did men get souls? Was the Missing Link capable of sin and therefore worthy of Hell? Did Pithecanthropus Erectus have moral responsibility? Was Homo Pekiniensis damned? Did Piltdown Man go to heaven? Any answer must be arbitrary.

But Darwinism – especially when crudely misinterpreted – threatened not only theological orthodoxy, but also the creed of eighteenth-century liberalism. Condorcet was a typical liberal philosopher of the eighteenth century; Malthus developed his theory to refute Condorcet; and Darwin's theory was suggested by Malthus's. Eighteenth-century liberals had a conception of man as absolute, in its way, as that of the theologians. There were the 'Rights of Man'; all men were equal; if one showed more ability than another, that was due entirely to a better education, as James Mill told his son to prevent him from becoming conceited.

We must ask again: Should Pithecanthropus, if still alive, enjoy 'The Rights of Man'? Would Homo Pekiniensis have been the equal of Newton if he could have gone to Cambridge? Was the Piltdown Man just as intelligent as the present inhabitants of that Sussex village? If you answer all these questions in the democratic sense, you can be pushed back to the anthropoid apes, and if you stick to your guns, you can be driven back ultimately on to the amoeba, which is absurd (to quote Euclid). You must therefore admit that men are not all congenitally equal, and that evolution proceeds by selecting favourable variations. You must admit that heredity has a

part in producing a good adult, and that education is not the only factor to be considered. If men are to be conventionally equal politically, it must be not because they are really equal biologically, but for some more specifically political reason. Such reflections have endangered political liberalism, though not, to my mind, justly.

The admission that men are not all equal in congenital endowment becomes dangerous when some group is singled out as superior or inferior. If you say that the rich are abler than the poor, or men than women, or white men than black men, or Germans than men of any other nation, you proclaim a doctrine which has no support in Darwinism, and which is almost certain to lead to either slavery or war. But such doctrines, however unwarrantable, have been proclaimed in the name of Darwinism. So has the ruthless theory that the weakest should be left to go to the wall, since this is Nature's method of progress. If it is by the struggle for existence that the race is improved – so say the devotees of this creed – let us welcome wars, the more destructive the better. And so we come back to Heraclitus, the first of Fascists, who said: 'Homer was wrong in saying "would that strife might perish from among gods and men". He did not see that he was praying for the destruction of the universe. . . . War is common to all, and strife is justice. . . . War is the father of all and king of all; and some he has made gods and some men, some bond and some free.'

It would be odd if the last effect of science were to revive a philosophy dating from 500 BC. This was to some extent true of Nietzsche and of the Nazis, but it is not true of any of the groups now powerful in the world. What *is* true is that science has immensely increased the sense of human power. But this

effect is more closely connected with science as technique than with science as philosophy. In this chapter I have tried to confine myself to science as a philosophy, leaving science as technique for later chapters. After we have considered science as technique I shall return to the philosophy of human power that it has seemed to suggest. I cannot accept this philosophy, which I believe to be very dangerous. But of that I will not speak yet.

Chapter 2

General Effects of Scientific Technique

Science, ever since the time of the Arabs, has had two functions: (1) to enable us to *know* things, and (2) to enable us to *do* things. The Greeks, with the exception of Archimedes, were only interested in the first of these. They had much curiosity about the world, but, since civilised people lived comfortably on slave labour, they had no interest in technique. Interest in the practical uses of science came first through superstition and magic. The Arabs wished to discover the philosopher's stone, the elixir of life, and how to transmute base metals into gold. In pursuing investigations having these purposes, they discovered many facts in chemistry, but they did not arrive at any valid and important general laws, and their technique remained elementary.

However, in the late Middle Ages, two discoveries were made which had a profound importance: they were gunpowder and the mariner's compass. It is not known who made these discoveries – the only thing certain is that it was *not* Roger Bacon.

The main importance of gunpowder, at first, was that it enabled central governments to subdue rebellious barons. Magna Carta would have never been won if John had possessed artillery. But although in this instance we may side