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III—SCIENCE

By Bertrand Russell

WESTERN civilization is derived from three sources: the Bible, the Greeks, and Science—the last operating chiefly through machines. The reconciliation between the Bible and the Greeks was a slow business, achieved in the course of centuries by the Catholic Church. The Renaissance and the Reformation undid the synthesis, and left the two elements again at war, as in antiquity. On the whole, Protestantism represented the Bible and free thought represented the Greeks. Pre-industrial America was biblical rather than Hellenic, and agricultural America has remained biblical, while industrial America is developing a new attitude, not hitherto known in the history of man. It is this new attitude that makes America interesting to the student of social science.

The effects of science are of two sorts, rather sharply separable. On the one hand, there is the scientific outlook as it exists in the man of science; on the other there is the transformation of ordinary life through the practical applications of scientific knowledge, more particularly through machines. The first is best seen in Germany; the second in America. Let us begin with the first, since historically it developed earlier than the other.

The Greeks are habitually praised by cultured persons on account of their literature and their art, but in these respects they were not very greatly superior to some other ancient nations, for example, the Chinese. Where they were unquestionably superior was in their invention of the deductive method and the science of geometry. Some few Greeks were scientific in the modern sense—nota-

bly Archimedes, who combined practice and theory, experiment and inference, in a thoroughly modern way. Some of the pre-Socratics, for example, Empedocles, were as scientific as was possible in the then state of knowledge. Aristotle is habitually praised for his extensive collection of facts, more especially in zoölogy; but the "Historia Animalium" shows that he was by no means careful to verify the tales brought him by those whom he employed, and that he did not realize the difficulty of accurate observation. Plato's influence was in the direction of emphasizing morals and metaphysics rather than experiment; and in later times this attitude prevailed more and more, so that Archimedes remained an isolated figure. Plato, one feels, was led by his aristocratic mentality to think it vulgar to do anything with one's hands, and the methods of the modern laboratory would have seemed to him beneath the dignity of a gentleman. These and other causes interfered with the development of experimental science in the ancient world, so that even what had been achieved came to be forgotten.

But there existed no such obstacles to the development of geometry. Until the work of Lobatchevsky in 1829, it seemed that the premises of geometry offered no difficulty, and that genuinely new knowledge about the actual world could be obtained by mere deduction. Consequently little attention was paid to premises and much to reasoning from them. This point of view dominated Greek philosophy and mediæval theology. To the outlook thus generated, particular facts were uninteresting except as the conclusions of syllogisms with general premises. The fact that Socrates was mortal was not ascertained from Plato's accounts of his last moments, but from the premise that all men are mortal. With the Renaissance, the actual was re-discovered: it became interesting on its own account, not as a mere instance of a general rule. There was at first a revolt against the intellectual tyranny of system, for example, in Montaigne, who hardly ever mentions general rules except to refute them by amusing exceptions. But men tired of intellectual anarchy, and invented a new discipline for the mind. The new discipline was the scientific method, which is already complete, as a method, in the writings of Galileo.

The essence of the scientific method is the discovery of general laws through the study of particular facts. It is thus a synthesis of the Greek and renaissance outlooks. Particular facts are the basis of the whole structure, but they are used for the purpose of induction, and when they have led to general laws inductively obtained, the Greek methods of deduction are applied to infer new particular facts from the laws. This method has had the most amazing success—amazing, because it is as indefensible intellectually as the purely deductive method of the Middle Ages. Hume long ago showed it up. All philosophy since his day has consisted of sophistical refutations of his arguments: the special skill of the philosopher has consisted in making his refutations so subtle and obscure that their fallacious character was not apparent. Men of science, meanwhile, have simply ignored Hume, and have marched from triumph to triumph. Gradually, however, more especially during the last thirteen years, the best men of science, as a result of technical progress, have been led more and more to a form of skepticism closely analogous to Hume's. Eddington, in expounding the theory of relativity, tends to the view that most so-called scientific laws are human conventions. Some of the leading authorities on the structure of the atom maintain explicitly that there are no causal laws in the physical world. And some philosophers hold the same view. "Superstition," says Wittgenstein, "consists of belief in causality."

This skepticism is a canker at the heart of science, affecting, as yet, only a few leaders, but capable, in time, of paralyzing the activities of the whole army of scientific workers. At least this would be the effect if men remained in the contemplative and intellectualistic mood. But science is becoming increasingly a manner of life, a way of behaving, and is developing a philosophy which substitutes for the old conception of knowledge the new conception of successful behavior. The more skepticism seems to result from a purely theoretic attitude, the more the practical pragmatic attitude triumphs. This is likely to become true throughout the world, but for the moment it is of course more true in a country like America, where the practical success of science is very evident, than in post-war Germany, where pessi-

mism and disillusion fit in with the prevailing tenor of the national life. It is therefore not surprising that America is leading the way in the transition from science as knowledge to science as a set of practical habits. On this ground, whoever is interested in the future should especially study America. To my mind, the best work that has been done anywhere in philosophy and psychology during the present century has been done in America. Its merit is due not so much to the individual ability of the men concerned as to their freedom from certain hampering traditions which the European man of learning inherits from the Middle Ages.

Perhaps these traditions can be summed up in the one word *contemplation*. European universities were originally places for the training of monks; and monks, though they tilled the soil, existed primarily for the sake of the contemplative life. A modern European professor does not till the soil, but he continues to believe in contemplation. In him this belief takes the form of admiration for pure learning regardless of its practical applications. I am myself sufficiently mediæval to feel this admiration far more strongly than it is felt by the typical modern man. Nevertheless, I perceive that it is psychologically connected with an attitude of reverence towards the universe which is hardly compatible with the modern belief in man's omnipotence through the machine. We do not contemplate a flea; we catch it. The modern point of view is in its infancy, but we may foresee a time when it will lead men to regard the non-human world in general with as little reverence as we now feel towards the poor flea. This means that the philosophy of an industrial world cannot be materialism, for materialism, just as much as theism, worships the power which it believes to exist outside Man. Pious Russia, barely emerging from Byzantine ecclesiasticism, has become officially materialistic; probably the more pious portions of the American population will have to pass through this same phase. But sophisticated America, wherever it has succeeded in shaking off slavery to Europe (which is too common among the sophisticated), has already developed a new outlook, mainly as a result of the work of James and Dewey. This new outlook, embodied in the so-called instrumental theory

of knowledge, constitutes the philosophy appropriate to industrialism, which is science in the sphere of practice.

The dominating belief of what may be called the industrial philosophy is that man is master of his fate, and need not submit tamely to the evils hitherto inflicted upon him by the niggardliness of inanimate nature or the follies of human nature. Man was in the past dependent upon the weather, which was beyond his control. This is still the case with peasants, who are usually pious, and still more so with fishermen, who are still more pious. It may be laid down broadly that the intensity of religious belief among sea-faring folk is inversely proportional to the size of their vessel. Accidents such as the sinking of the *Titanic,* however, tend to keep some measure of religion alive even in the largest ships. But this state of affairs is passing, and its passing is accelerated by every increase in the safety of navigation.

Man, since he became capable of forethought, has been dominated by fears—fear of natural phenomena such as lightning and tempest, fear of starvation, fear of pestilence, fear of defeat in war, fear of murder by private enemies. Elaborate systems, partly rational, partly magical, have been built up to minimize these dangers. In the early ages of agriculture men dealt with the fear of starvation by means of human sacrifice, which was supposed to invigorate the Corn Spirit. It is only very gradually that scientific agriculture has displaced this attitude. Inundations, except in China, were usually dealt with by prayer to the River God. There was a general tendency to regard misfortunes as due to the anger of invisible beings, who could be propitiated by suitable ceremonies. Pestilence was viewed superstitiously down to our own day, and is still so viewed in India. The fear of war has only just begun to be treated rationally, and those who so treat it still labor under the suspicion of being cranks. Our natural view of the causes of war is more consonant with Coleridge's:

> *Kubla heard from far*
> *Ancestral voices prophesying war.*

The fear of murder by private enemies is supposed to be dealt with by the criminal law. But the criminal law, also, was in its origin

superstitious, being based upon the notion of blood pollution. Even now, our emotion towards an ancient crime, such as murder, is quite different from that towards (say) forgery, which has no roots in the superstitious past. And even now, the retributive element in punishment, which is superstitious, being based upon the rage inspired by fear of the criminal, prevents our criminal law from being as effective as it might be in the prevention of crime.

Few people realize how very modern is the influence of science upon the intellectual outlook of cultivated men, let alone the ordinary citizen of a civilized community. The Greeks, and the Romans in their best days, were, it is true, not dominated by fear. But their hopes had a different quality from ours. Compare Plato's "Republic" with any of Wells' Utopias. In Plato's hopes, men were to advance in virtue, and in a certain kind of wisdom; but he did not think of greater dominion over nature as an ingredient in the good life. Perhaps the reason for this was in part economic: where labor is performed by slaves, the free-man is not impressed with the importance of minimizing labor. But other more intellectual reasons played their part. Geometry led men to think that the truth could be discovered by reasoning, or, as Plato suggested, by reminiscence. Moral and æsthetic considerations were allowed an undue weight in framing hypotheses about the physical world: it was supposed that the physical world must be beautiful and intellectually agreeable to contemplate, which led to a preference for simple hypotheses, such as that the heavenly bodies moved in orbits which were circles or combinations of circles. As the intellectual vigor of the ancient world declined, authority became supreme, and commentaries took the place of fresh thought. Thus, although a few Greeks had achieved a scientific outlook, the ordinary cultivated man had a view of the world in which scientific investigation played no part.

This is no longer quite true of the Arabic civilization, which certainly had more scientific curiosity than the later Hellenistic centuries. But a great deal of superstition is mixed with science in all but the best of the Arabs. Alchemy, the search for the philosopher's stone, the attempt to discover the elixir of life, occupied many experimenters' thoughts to the exclusion of more genuine

problems. In Europe, meanwhile, the over-emphasis on ethical considerations which is visible in all Greek post-Socratic philosophy, and the subsequent undue respect for authority which was both effect and cause of intellectual inferiority to earlier centuries, prevented almost all scientific investigation throughout the Middle Ages, except by those few men who, like Roger Bacon, had been stimulated by contact with the learning of the Moors. For all these reasons, science played hardly any part in life, even for the small learned minority, until the Renaissance.

The Renaissance was, of course, primarily a literary movement, involving, at first, not an emancipation from authority, but only a change, more especially from Aristotle to Plato. However, when men realized that the ancients had disagreed with each other, they were forced to think for themselves to decide which ancient author they should follow. Copernicus discovered in Italy that some of the Greeks had taught that the earth goes round the sun; if he had not known this, it may be doubted whether he would have had the courage to propound his theory, in favor of which he had no very solid scientific reasons to offer.

Kepler and Galileo represent the real beginnings of modern science; it is in them that we first find the patient and unbiassed observation of large numbers of particular facts, leading to the formulation of laws which they had not expected. The contemporaries of Galileo, especially the most learned, objected to his habit of ascertaining facts by looking at the world instead of at Aristotle. But the time was at last ripe for the victory of science. In an earlier age, Galileo might have been forgotten; as it was, a series of incredibly brilliant successors carried on his work quickly to its completion in Newton's "Principia."

Throughout the seventeenth and eighteenth centuries, though science had to fight against both theology and the humanities, it acquired an increasing ascendancy over the minds of educated men. But until after the end of this period science was conceived almost wholly from the standpoint of theoretical knowledge. It is true that Bacon had said "knowledge is power," and had viewed knowledge in relation to its practical uses. But astronomy, the dominating science of the time, had not much utility except for

navigation, and there only in its elementary portions. The inventions which made physics and chemistry useful had not yet been made, or at any rate had not yet achieved success. The motive of men of science, accordingly, was to understand the world, not to change it. This is still the motive of those who make the great theoretical advances—Einstein, Planck, Bohr, and such men. But everybody now-a-days is aware that science is likely to have practical applications, and this has greatly modified the prevailing view of the purposes of science.

From the time when Charles II founded the Royal Society down to the outbreak of the French Revolution, science was associated with "enlightenment." At first, it was a cure for "enthusiasm," i. e., for the kind of fanaticism that had been displayed by the Puritans. Then, in France, in spite of the fact that both Jesuits and Jansenists had produced many admirable men of science, the pursuit of mathematical physics became gradually associated with materialism, with opposition to the Church, and with political radicalism. This movement culminated in the Revolution, which produced, throughout Europe, a temporary diminution in the rate of scientific progress.

It is only in the nineteenth century that science came to be commonly regarded as affording a means of improving the general level of human life, not by moral regeneration, and not by political reform, but by increasing man's command over the forces of nature. This point of view was, of course, due to the industrial revolution, and to various inventions, such as steamships, railways, and telegraphs. This view of science as the handmaid of industry has now become a commonplace. As already observed, it is now possible to hope that mankind may, to a very great degree, be freed from certain age-long terrors—pestilence, famine, drought, and flood, perhaps even war.

Science, in so far as it is successful, eliminates these various kinds of fear from our lives. It cannot, of course, altogether eliminate the fear of death, but it can and does cause us to live longer than our ancestors, and to this process no definite limit can be set. Fear of natural phenomena plays a very small part in modern urban life. Once in a way, some event such as the Tokyo

earthquake reminds us that Nature is not yet wholly subdued. Taking a longer view, science assures us that our planet will not always remain habitable, and that, although we may migrate to Venus when the sun's heat diminishes, that can only put off the date of our extinction by a million years or so. These distant speculations, however, have no power to disturb the urban worker as he hurries for his morning train. His emotional world is a human one, trivial, boring, but safe—except from the anger of the boss. And so politics increasingly takes the place of religion, since it is in the sphere of politics that fear now finds its home.

It may be said that, while science has already greatly diminished the fear of nature, it has so far, if anything, somewhat increased men's fear of each other. Lightning conductors, which George III (rightly, as I think) regarded as impious, have destroyed fear of "the all-dreaded thunder-stone." But other inventions have enabled man to wield powers as destructive as those formerly wielded by Nature. And science has made society more organic, so that on the one hand the rebel finds it increasingly difficult to escape the vengeance of the holders of power, while on the other hand social chaos, when it occurs, becomes a much greater disaster than in more primitive communities. Perhaps for these reasons, the pressure of the herd and the fear of neighbors, are greater in America than in any other civilized country. While man collectively has been freed from bondage to the non-human world, men individually are held in bondage to their fellow-men more completely than in the pre-scientific ages.

Will science, in the end, deal also with this form of fear? I think it will. Hitherto, the practical applications of science have been mainly directed to modifications of our material environment. Whereas formerly the environment was a datum, something to be merely accepted and contemplated, it is now, so far as the surface of the earth is concerned, raw material for human manipulation. But human nature is still accepted as a datum. While we alter the environment to suit ourselves, we do not much alter ourselves to suit each other. The reason is, of course, that the sciences that deal with the formation of human character are far less developed than those that deal with the inanimate world. This, however, is

rapidly changing. It is highly probable that in a hundred years we shall have acquired the same control over the characters of children that we now have over physical forces. We shall then, if we feel so disposed, be able to eliminate fear from the relations between human beings as we are already eliminating it from the relations of human beings with the world of nature. But what men will make of these powers when they come to possess them, it would be very rash to prophesy. Doubtless they will make something which, to our inherited standard of values, would seem horrible; but to them, one must suppose, it will seem good. Let us, then, console ourselves as best we may with Hamlet's dictum:

There's nothing either good or bad but thinking makes it so.

A good community is one that those who live in it think good; and that, at least, the scientific educators of the future will almost certainly be able to secure.

The philosophy inspired by industrialism is seeping away the static conception of knowledge which dominated both mediæval and modern philosophy, and has substituted what it calls the Instrumental Theory, the very name of which is suggested by machinery. In the Instrumental Theory, there is not a single state of mind which consists of knowing a truth—there is a way of acting, a manner of handling the environment, which is appropriate, and whose appropriateness constitutes what alone can be called knowledge as these philosophers understand it. One might sum up this theory by a definition: *To know something is to be able to change it as we wish.* There is no place in this outlook for the beatific vision, nor for any notion of final excellence.

This "dynamic" conception of knowledge and of value is so ingrained in most typical modern men that they are incapable of understanding the nostalgia which it produces in a sensitive European impregnated with the older culture. European countries (except Russia) differ far less from each other than all differ from the United States. It is perhaps worth while to consider this difference impartially, since any forecast of the development of machine civilization based upon European experience is likely to prove fallacious.

The last cantos of the "Divina Commedia" may serve to illustrate the point. In these the supreme bliss is represented as a combination of contemplation and love, both at the highest pitch of intensity, but wholly static, because perfection has been achieved and nothing is left to strive for. In Milton, more briefly, we find the same conception of heaven:

Where the bright seraphim in burning row
Their loud uplifted angel trumpets blow,
And the cherubic hosts in thousand quires
Touch their immortal harps of golden wires.

It is not suggested that the trumpets and harps should be of continually improved makes, or should be played by machinery to save the angels trouble and leave them free to increase the height of the buildings in the Golden City.

The modern European artist or man of learning knows that the beatific vision cannot constitute the whole of his life, and is skeptical of any life hereafter. But if he is sensitive, whether as an artist or a man of science, a lover or an explorer, he lives for the moments which approach nearest to the ultimate ecstasy, when he is "silent upon a peak in Darien." This is as true in the pursuit of knowledge as in that of beauty, for in a new theoretic insight he finds a rapture as intense as that of new love.

Such men, however, are to be regarded as strayed ghosts from an earlier epoch. Men do not always belong to their own time: eminent men are often psychologically ahead of this epoch, but are sometimes behind it. Dante, for example, sums up preceding centuries, and does not suggest the future in anything except his use of the Italian language. It is a curious speculation to consider what various men of past ages would think of our civilization if they were miraculously transported into it. Archimedes, I fancy, would find it wholly delightful. He would indefatigably visit factories, observatories, scientific instrument makers; he would read encyclopædias from cover to cover; he would be immensely impressed by wireless telegraphy, and beside himself with joy over aeroplanes. He would admire, above all things, our means of sci-

entific warfare, but would be unable to understand why they are not used to exterminate the barbarians. He would master our science and our mathematics in a few years of intense study, but our politics would puzzle him—not so much what we do, but what we say, though what we do, also, would be in part unintelligible to him.

Aristotle, I fancy, would divide his time between Oxford Common Rooms and the Zoo. In the latter, he would question the keepers as to the habits of their animals, and would be led to amend what he says on cures for insomnia in elephants. In the former, his conversation on metaphysics would be better appreciated than anywhere else in the modern world, but he would be surprised by the lack of interest in zoölogy. He would make friends with explorers and statesmen, and would take a considerable interest in anthropology. But the mechanical aspects of our civilization would bore him, and he would be profoundly shocked by democracy. (So, indeed, would even the most democratic of the Greeks.) He would not use the subway unless he could have a special train for himself and his friends.

Plato, if he could return to this world, would make friends with Dean Inge and accept his views on modern civilization *in toto.*

Bacon would be appointed editor of the Encyclopædia Britannica; but would be dismissed for inserting advertising matter under the guise of articles. He would admire museums, card catalogues, and machine politicians. He would enthusiastically praise industrial technique, but would regard relativity and quantum theory as unduly subtle, and as fantastic speculations of no practical importance. He would have many friends among the eminent, and would feel thoroughly at home in our world as soon as he had acquired a comfortable fortune.

Newton, I fancy, would regret that he had ever allowed the world to become acquainted with his researches. He would be fairly happy so long as he remained within the gates of Trinity College, but motor cars and even bicycles would alarm him, and he would say that whenever he began to think about mathematics they ran into him. Machines, he would complain, have made

present-day England less agreeable to the philosopher than the England of Queen Anne. And as Master of the Mint he would be inexpressibly shocked to find that paper had taken the place of gold.

I fear that a passion for psychological truth has led me to make these imagined reactions of distinguished ghosts more trivial than seems appropriate to their eminence, except in the case of Archimedes. Even the greatest men, however, are often influenced by very minor factors in forming their judgments; and this is an important fact, which should put us on our guard in attempting to sum up our own age. When we try to be as objective as possible in singling out the most important external differences between the present and the past before the nineteenth century, I think the following deserve emphasis.

First: greater mobility both of men and goods. From the time when the horse was first domesticated down to the invention of the locomotive, the greatest possible speed of land travel remained approximately constant. The Imperial Post in the Roman Empire travelled at about the same rate as Dickens' stage coaches. Trains made a rapid revolution, but soon achieved very nearly their present speed. Aeroplanes represent a new revolution. Sea travel, although there was a vast addition to geographical knowledge, did not very greatly increase in speed until the invention of steamboats.

Second: speed in sending messages. Here the three stages, so far, are the telegraph, the telephone, and wireless. It is theoretically impossible to surpass the speed of wireless, which is that of light. In this matter, therefore, we have, in a certain sense, achieved perfection.

Third: the substitution of machinery for handicrafts in industry, with the consequent enormous increase of material well-being in all classes.

Fourth: the improvement in public health, which has been particularly noteworthy since the beginning of the present century.

Fifth: the application of science to methods of warfare. But this is a trite theme, as to which I propose to say nothing further.

The intellectual changes brought about by science are in part

considerably older than the above practical changes, but in part they also belong to the last hundred years. It may be said, broadly, that science has simultaneously, and in equal measure, increased man's power and diminished his pride. In the Middle Ages, the earth was the centre of the universe, and the human race was the principal object of divine solicitude. The first blow to this outlook, and perhaps the greatest, was the Copernican system, with the discovery that the earth is one of the smaller planets. The next blow was the doctrine of evolution, as to which traditionalists are still fighting a rearguard action. The next, which is only now beginning to be delivered, is the analysis of mind and soul by behaviorists and bio-chemists. I have heard it suggested by a bio-chemist that mysticism is due to excessive alkalinity of the blood. This particular doctrine may or may not be true, but some equally painful explanation of the mystic emotion is pretty sure to be found before long. Physics, biology, psychology, have each in turn passed over from superstition to science, and have each in turn demanded sacrifices dear to our human conceit. The increase of power which men derive from science has, however, made these sacrifices endurable, and has allowed the scientific outlook to triumph in practice even with those who continue to reject it in its general and speculative aspects.

Theoretical science itself has changed its character in the course of its development. Newton's "Principia" has a statuesque perfection; a modern man of science does not attempt to give his work this character. Final truth is no longer demanded of a scientific theory, or claimed for it by its inventor. There is no longer the same conception of "truth" as something eternal, static, exact, and yet ascertainable. Consequently even the best modern theories are more satisfying to the practical than to the theoretical side of our nature. The more physics advances, the less it professes to tell us about the external world. To the Greek atomist, an atom was a little hard lump, just like an ordinary body except that it was small. To the modern physicist, it is a set of radiations coming out from a centre, and as to what there may be in the centre nothing can be known. Even when we say that there are radiations coming out from a centre, we are saying some-

thing which, when correctly interpreted, is found to mean much less than it seems to mean at first sight. More and more, science becomes the art of manipulating nature, not a theoretical understanding of nature. The hope of understanding the world is itself one of those day-dreams that science tends to dissipate. This was not formerly the case; it is an outcome of the physics of the last twenty-five years. Undoubtedly it tends to strengthen the instrumentalist philosophy.

The influence of the theory of relativity has been in this same direction. Einstein's law of gravitation is better than Newton's, and represents an equal triumph of human genius; but its effect upon scientific mentality has been quite different. Both in England and in France, Newton's work led men to think that they had at last penetrated the secrets of the universe; fine ladies tried to understand the "Principia," and philosophers took pleasure in expounding it to them. But Einstein's work has, on the whole, made men think that they know less than they had supposed. It seems that, although physics enables us, within certain limits, to predict our own experiences, it gives us only an abstract and formal kind of knowledge concerning what lies outside. If we continue to use pictorial language, and say (for example) that the earth describes an orbit round the sun, we must not suppose that "earth" and "sun" and "orbit" mean what one naturally imagines them to mean—they are merely names for certain mathematical expressions. Einstein, therefore, has not brought men the same sense of triumph as Newton brought, although his work is just as remarkable. "Laws of nature" have turned out to be in some cases human conventions, in others mere statistical averages. This may not be always the case, but at any rate the old glad certainty is gone.

In conclusion, I wish to consider some of the social effects of science, and some of the hopes and fears for the future to which these effects give rise.

There is one regrettable feature of scientific civilization as hitherto developed: I mean, the diminution in the value and independence of the individual. Great enterprises tend more and more to be collective, and in an industrialized world the interference of the

community with the individual must be more intense than it need be in a commercial or agricultural régime. Although machinery makes man collectively more lordly in his attitude towards nature, it tends to make the individual man more submissive to his group. Perhaps this is one cause of the fact that herd instinct is much more insistent in America than in England, and that individual liberty is less respected both politically and socially. I think, however, that a more important cause is the mixture of races and nationalities in the United States, which makes herd instinct a necessary unifying force. Even if a diminution of individual liberty be an essential feature of a scientific civilization, the mastery over nature is so great a boon that it is worth while to pay even a high price in order to achieve it. And it is probable that, as men's habits become more adjusted to the new régime, the interference with liberty will become very much less.

The omnipotence of man collectively and the feebleness of each individual man, which are features of a scientific civilization, should logically entail certain changes in values, religious, moral, and æsthetic. Belief in the infinite value of the individual soul arose as a consolation for the powerless subjects of the Roman Empire: ego-compensation had to be placed in another world, because the ordinary man had no share of political power. In the modern machine-world, owing to democracy and to the achievements of science, other compensations are possible, more especially nationalism, which identifies the individual emotionally with the power of his group. But in order that such compensations may satisfy, it is necessary to belittle the individual wherever he is not contributing to a totality. Lyric love, for example, which has inspired half the poetry of the world, has been a product of courts and aristocracies. Its revival after the Dark Ages was due to the Emperor Frederick II. The loves of an Emperor were events of public importance, and he saw nothing ridiculous in taking them seriously. His courtiers saw nothing ridiculous in imitating him. And so lyric love became a tradition. But in a civilization dominated by the machine, such seriousness about a mere emotion is impossible.

Changes in religion and morals come slowly, owing to our emo-

tional resistance; yet they seem almost inevitable if a scientific civilization remains dominant for several centuries. In morals, we may expect a substitution of hope for fear, and an increase in the sense of the rights of the community as against the individual. Traditional morality, historically, was concerned with the relation of the individual soul to God. Political obligations formed part of the republican morality of Greece and Rome, but not of early Christianity, which grew up among populations without political power and therefore without political responsibility. This explains why many people still consider adultery a greater crime than acceptance of bribes by a politician or public official. Again: the State increasingly interferes between parents and children—for example, by insisting on education and forbidding physical cruelty. It would seem likely that this tendency will continue; more particularly, the State may be expected to assume the role of the father by taking over economic responsibility for the child, on the ground that many fathers cannot be trusted in this matter. If so, there will inevitably be a breakdown of the family, which must modify social psychology profoundly, producing, in place of individuals, well-drilled armies of intelligent but submissive Janissaries, without individual differences, and without loyalties other than their loyalty to the State.

There remains the question: Can a scientific society be stable? Or does it contain within itself some poison which must ultimately produce its downfall? The Greeks produced an admirable way of life, but it was incapable of survival. Something of what they created passed into the Roman Empire, and thence into the Catholic Church, but in a diluted form. So it may be that the intensity of the scientific element in life will have to be diminished before men arrive at a stable polity. This possibility is worth examining.

There is, to begin with, an intellectual inconsistency in the scientific outlook. The nominal practice of science is to accept nothing without evidence, to test all its assertions by means of facts. But in reality, as Dr. Whitehead has pointed out in "Science and the Modern World," science has dogmas as ill grounded as those of any theological system. All science rests

upon induction, and induction rests upon what Mr. Santayana calls "animal faith." The proofs of the validity of induction are as numerous as the proofs of the existence of God; but not one of them is calculated to carry conviction to a candid mind. This will not impede the progress of science so long as most men of science remain genuinely unaware of their theoretical insecurity, but as soon as they have to practise a semi-deliberate shutting of the eyes, they will lose the ardor of fearless explorers, and will tend to become defenders of orthodoxy. If, on the other hand, the instrumental theory of knowledge prevails, and theoretical problems are put to one side as merely scholastic, the inspiration to fundamental discoveries will fail. I am not arguing that the instrumental theory is false; on the contrary, I incline to think that it is true. But I am arguing that it does not afford a sufficient incentive to the precarious labor of serious thinking. When Egyptian priests discovered the periodicity of eclipses, they did so because superstition had led them to record such phenomena with scrupulous care. A false belief may be an essential ingredient in discovery, and perhaps the progress of science will cease on the day when the men of science become completely scientific. If so, they will turn to superstition for relief, and the Dark Ages will return. All this, however, is no more than a doubtful speculation.

More serious is the effect of a scientific civilization upon population—not upon quantity, which is unimportant, but upon quality. The most intelligent individuals, on the average, breed least, and do not breed enough to keep their numbers constant. Unless new incentives are discovered to induce them to breed, they will soon not be sufficiently numerous to supply the intelligence needed for maintaining a highly technical and elaborate system. And new incentives will have to be far more powerful than any that seem politically feasible in any measurable future. In America and Great Britain, the fetish of democracy stands in the way; in Russia, the Marxian disbelief in biology. Wherever the Catholic Church is strong, mere quantity tends to be thought alone important. In France, the economic system that has grown up around the Code Napoléon makes any eugenic reform impossible.

Probably the best chance is in Germany, but even there it is small. Meanwhile, we must expect, at any rate for the next hundred years, that each generation will be congenitally stupider than its predecessor. This is a grave prospect.

In the ancient world, it is clear that Greece in the age of Pericles and Rome in the Augustan age were more intelligent than at later times; it is also fairly clear that the decay of Rome was primarily a decay of intelligence. Will this kind of decadence repeat itself? Not if biological science can obtain the same hold over men's minds as physical and mechanical sciences have now. In that case, by positive and negative eugenics the average intelligence can be increased in each generation, instead of being diminished, as at present. Unfortunately the concern of biology is with the most intimate part of human life, where emotions, morals, and religion alike stand in the way of progress. It may be doubted whether human nature could bear so great an interference with the life of instinct as would be involved in a really effective application of eugenics. Whatever may be thought disagreeable in the machine age would be greatly intensified by the application of science to parenthood, and men might well think the price not worth paying.

What does seem clear is that we cannot stand still with the measure of science that exists at present in western civilization. We must either have more science, in particular biological science, or gradually become incapable of wielding the science we already have. In that case the forces of ignorance and obscurantism will gradually creep back into power. For a while, the old machinery will survive, just as Roman aqueducts survived in the sixth and seventh centuries; but gradually there will be an increasing collapse, until the skyscrapers become as strange as Maya ruins in Yucatan. Let us not flatter ourselves that this is impossible; all past history proves the reverse.

In the course of this chapter, I have not sought to minimize what may be considered the defects of the machine civilization. I do not doubt, however, that its merits far outweigh its defects. Take two items alone: the diminution of poverty, and the improvement in public health. These two alone represent an almost

incalculable increase in average happiness, and each of them is capable of being carried very much further than has yet been done.

The remedy for the one-sidedness and harshness of our present civilization is to be sought, not in less science, but in more. Psychology, physiology, and the study of heredity have much to contribute. But if they are to add to human happiness, it is essential that we should learn to use the machine without worshipping it. Studies of industrial fatigue with a view to facilitating a greater output are not the most important part of psychology. The effect of stimulants in diminishing work on Monday morning is not their only effect deserving of study. Nor is suitability as a factory hand the only quality the eugenist should aim at producing. The machine was made for man, not man for the machine. The important thing about work is that it affords leisure for play; if it does not do this, it is not fulfilling its social purposes. When the same scientific acumen comes to be applied to human nature as has already been applied to the physical world, it may be expected, with some confidence, that the importance of happiness will no longer be forgotten. And evidently the honeymoon intoxication of the machine age will pass soonest in the countries which have been the first to experience it. I look, therefore, to the western nations, and more particularly to America, to establish first that more humane, more stable, and more truly scientific civilization towards which, as I hope, the world is tending.