

ENVIRONMENT

A MAGAZINE OF SCIENCE

Issued once each term in the interests of The
Science Teachers' Association of N.S.W.

VOLUME II.

AUGUST, 1935.

NUMBER 3.

SCIENCE AND MANKIND.

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IN this article I can give you the merest outline of something of what science has done for humanity in the past, but I hope I may be able to impress upon some of you at least the conviction—or to strengthen your conviction if you already hold it—that science has been in the past, and will continue to be in the future, the most powerful of all instrumentalities which men can use to advance human welfare.

I would not, however, be so rash as to claim that scientific knowledge alone is sufficient, for even if we accept the truth of the old adage "Knowledge is power", we cannot shut our eyes to the fact that like other more material sources of power, knowledge may and often does lie unused and barren of all performance—buried, as it were, in the mind like oil and coal in the earth, under an overlying burden of inert matter, and never coming to the living surface of the mind to be employed in its activities. To be effective, knowledge must of course be combined with action, and history shows that scientific knowledge has ever been most effective, most fruitful in results, when combined with the exercise of the artistic faculty of invention.

It must be frankly allowed, also, that science and invention can be turned to base and evil uses just as well as to good and useful ones. Science belongs to the intellectual side of the human mind, it is an instrument of the other side—the spiritual—from which arise our hopes and our fears, our hates and our loves, our desires and our ambitions, our sense of æsthetic and of ethical value, in short all those feelings and emotions which impel us to action.

These statements are merely made by way of introduction and to avoid misunderstandings. Let me now



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commence with a brief explanation of what the word *science* implies. I have used it above as equivalent to *knowledge*, and certainly this is the meaning of the Latin word "scientia", from which it is derived. But science as the word is now used has come to mean both more and less than knowledge in the ordinary sense of that word.

We all know that Bradman made 244 runs in the last test; that Queen Anne had fourteen children, all of whom died in childhood—a fact I shall make use of later—and that the next Federal election will be held—when will it be held? I'm sure I don't know—and a hundred thousand other things of the same kind, all of which are knowledge of a sort, but of a sort which I think none of you would wish to dignify with the term "science".

Nor is everything that our eyes and our ears tell us to be regarded as scientific fact. Our eyes tell us that the bright star Alph Centauri—the brightest of the two "pointers"—is a single star, that the sun—or the moon—is larger when rising than when overhead, and that there is nothing in an empty bottle. All of these statements are false. Our eyes have deceived us into believing that which is not.

The ears of a savage, also those of certain modern broadcast listeners, cannot distinguish between a jumble of noises and a musical composition; the squeak of a bat is silence to many; the muffled beat of a drum to others. Our ears as well as our eyes may misinform us. The information they give us is not scientific.

Scientific statements are distinguished, on the one hand, by their general or abstract nature; they comprehend not a single isolated fact such as those cited above, but a whole multitude of similar facts, as when we include the falling of stones, the march of a planet around the sun, and the universal attraction of bodies in the one law of gravitation; and, on the other hand, in scientific descriptions of fact the information conveyed by the eye or ear or other sense, often incomplete, often inaccurate, sometimes quite erroneous, and at most always coloured by the personal peculiarities and limitations of the observer, is extended, corrected, made precise, and put in a form which makes it equally true for all intelligent beings at all times and all places. An enormous extension in the range of information and vastly superior accuracy of detail can be attained by the use of instruments such as the telescope, the microscope, the spectroscope, the photographic camera and other instruments which detect a wide range of radiation, such

as heat waves and X-rays, totally unperceivable by the eyes.

Such ideas as colour, and brightness, the estimation of which may vary very widely with different people and in different circumstances—for as we know certain people are entirely blind to certain colours and cannot, for example, distinguish red from green—such subjective terms are replaced by purely objective conceptions such as wave-length or energy-intensity capable of precise measurement, and entirely independent of the observer's limitations or idiosyncrasies.

What is still more important is that a method has been developed—known as the scientific method—of arranging, classifying, and interpreting these data, obtained by observation in accordance with certain definite principles of logical thinking, and of welding together all the facts in the same field of observation—as e.g. in astronomy, or mechanics, or electricity, or chemistry, or botany, or embryology, or psychology (I could name a score of other 'ologies) of welding together all the facts, I say, into a connected whole which forms a scientific theory or a special science so that not only can they be comprehended with comparative ease—and otherwise than by this scientific method they cannot be comprehended at all—but they all stand together with a surety which is at least a hundred thousand million times greater than that of any isolated fact can possibly be.

It is for this reason that scientific men distrust statements of isolated fact made on the extremely fallible basis of individual testimony only—such as the working of a perpetual motion machine, or the miraculous suspension of a coffin between earth and heaven, or the appearance of disembodied spirits—which do not fall within this body of science, and which conflict with its surely established generalisations. I would not claim, however, that scepticism with regard to such statements is exclusively an attribute of the scientific attitude of mind; it is common to all who have a proper regard for the dignity of truth.

I have said enough or too much of the nature of science. It is time that I made some attempt to justify the claims I made at the outset regarding the supreme value of science for human well-being and progress.

Let us take a look backward into the past—no further, at first, than my own boyhood, half a century ago. What marvellous changes have taken place. Today we enjoy the convenience and the advantage of being able to travel swiftly and comfortably from place to place by a

variety of means: the steam locomotive on the railway, the electric tramcar, the motor car or motor bicycle, the ordinary bicycle—not to mention the aeroplane (which will presently be the universal mode of long distance passenger transport). It is difficult, I am sure, for the younger generation to realise that, only half a century ago, the railway was the only one of these in existence except the old type of bicycle. Our homes, when I was a boy, were dimly lighted—excepting in city areas supplied by gas—by candles, or at best by oil lamps. As regards mail communication the telephone was in its infancy, wireless of course undreamed of.

In the realm of industry half a century ago the steam engine, along with the windmill, and the water wheel was the only source of motive power except horse-power and man-power. The electric motor which probably drives nine-tenths of the machines in the world today was still a puny infant.

All these contrivances, which we have today and fifty years ago had not, and a thousand other labour-saving, time-saving, trouble-saving, money-saving, comfort-giving, health-giving, wealth-giving inventions we owe to science—chiefly to mechanical, electrical and chemical science—combined, of course, with the technical skill of the designer or engineer or artisan required for their design and construction.

In the face of these facts no one, not even the bitterest enemy or detractor of science, could, if he would, deny the immense power of achievement which comes from a combination of scientific knowledge and method with technical skill in construction and with inventive genius. But some may yet be critical or dubious concerning the advantages to men of such an increase in their material power and wealth. Some may even contrast the present age, which enjoys these gifts of science, with the "good old times" when as they profess to believe, in spite of, or even because of, the lack of the advantages and luxuries of the present day, men lived simpler, healthier, happier lives.

Let us see what sort of evidence there is to support or refute this view. Of course it is impossible to make a complete survey of the history of mankind throughout the world and throughout the ages. To do so would be to write a history of civilisation such as perhaps only Mr. H. G. Wells among living authors is competent to write, and I would refer those who want to hear more of

it to his extraordinarily interesting book "An Outline of History".

I will only attempt to illustrate my theme of the dependence of human progress and well-being on the advance of science by reference to one or two other important aspects of human society other than that of mechanical invention.

Let me first deal with the question of health and disease. I mentioned a little while ago the fact that all of Queen Anne's fourteen children died in childhood. This instance of infantile mortality in those times is not exceptional. The average age of man or woman in the days of Good Queen Bess was only 20. Today it is 55. That fact alone is most significant.

In the year 1927 I was privileged, while on a visit to London, to attend the Centenary celebrations held by the British Medical Association in honour of the great surgeon Sir Joseph Lister who, as you all know, was the first to apply the discoveries of the French scientist Louis Pasteur to the prevention of sepsis or infection of open wounds. I would like to repeat to you one or two extracts from the various addresses which were given by men eminent in medical science on that occasion. Before the days of Lister and antiseptic surgery, we were told, nearly 50% of those who underwent the simple operation of amputation of a limb died, either as a result of the operation itself or, more usually, from the blood-poisoning due to the sepsis which invariably supervened upon it. It was also stated that the amount of putrescence in a hospital was so appalling that a hospital could be recognised from afar by its stench.

In modern times the surgical wards of a hospital still insistently proclaim their function to our olfactory sense, but the odour which pervades them now is the healthy, if not fragrant, emanation from the iodine or other antiseptics used in dressing the wounds of the patients. The death of a patient from sepsis today is regarded as a reproach to surgeon or hospital staff, or both. If we look further back into the good old times we find even more striking confirmation of their lack of sanitary virtue. Even our school histories, records for the most part of such banalities as Acts of Parliament and Royal misdemeanours, and, of course, perpetual wars, find space to mention one or two of these, such as the Black Death of the 14th century, which at one stroke wiped out nearly one-half of England's total population of five millions,

and the Great Plague of 1665, of which nearly 100,000 died in London alone.

These holocausts were by no means unusual. In fact many frightful diseases practically unknown in this favoured country and rare now in Europe, such as smallpox, leprosy, malaria and cholera, seem to have been chronic in Europe a few hundred years ago, and this perpetual prevalence of disease, together with the frequent recurrence of periods of famine in which tens of thousands died of starvation (the 12th, 13th and 14th centuries averaged one famine to fourteen years), and, of course, the incessant warfare between the nations, it was which kept the population of Europe down to one-tenth of its present number.

It is startling to read that in the 13th century—only 700 years ago—there were 2,000 lazarettos in France alone. Leprosy, smallpox, bubonic plague and other fell diseases of man are now almost unknown in Europe, though still endemic among the crowded populations of Asia, where the mass of the people still live under conditions of the same charming simplicity in respect of hygiene and sanitation which existed in Europe in the Middle Ages.

What has brought about the disappearance of these dreadful scourges? In many cases simply a scientific recognition of their causes, rooted mainly in the absence of sanitation as we now understand that term or, it may be, the identification of some carrier of the disease, such as the flea, which is the vector of bubonic plague germs, or the mosquito, which is responsible for the transmission of the germs of malaria and of yellow fever. It has been truly said that the application of scientific methods to the problems of human health and disease has achieved more in the last half century than was accomplished in the previous twenty centuries of human history by means of casual observation—liberally seasoned with superstition.

It would be easy to offer unlimited evidence on the influence of scientific discovery and invention upon the health of the body social, and in removing social diseases, such as poverty—the worst of all, for out of it arise the others, crime, drunkenness, mendicancy, etc. I shall content myself with a brief reference to the institution of slavery. This custom, which we today look upon as barbaric and horrible, was an invariable feature of all early civilisations, including European. It lasted in Britain well on into the 18th century. In fact the last law abolishing perpetual servitude in Scotland was passed only in 1799. Until quite recent times, therefore, slavery was a social institution condemned neither by law, by

religion, nor by public opinion. Today it is repudiated by all three. What has brought about this revolution in human ideas? Many would say, no doubt, the growth of humanitarian ideals. Exponents of humanitarian ideals, however, were not lacking prior to the 18th century, and it is strange to find that some of the greatest humanistic teachers, such as Plato, looked upon slavery as a justifiable and indispensable practice. Nine-tenths of the population of Greece in his time were slaves. Is it possible to regard it as a mere coincidence that anti-slavery sentiment as a practical social and political force coincided with the advent of the industrial revolution brought about by the introduction of steam power? If so, it is a remarkable coincidence. No; the wickedness and inhumanity of slavery became manifest to all as soon as it was discovered that work could be done more effectively and more cheaply by steam-driven machinery than by the labour of slaves. It is worthy of note, also, that the anti-slavery movement originated and gained strength in those countries such as England and the northern States of America in which steam power was most extensively employed *and which manufactured and sold industrial machinery*. Let us render all honour to Wilberforce and his fellow-workers in the cause of human freedom, but let us not omit to recognise that without the invention of Watt and Crompton and Arkwright which made it possible to abolish slavery and at the same time attain a higher level of wealth and culture, their efforts would certainly have found little response among the ruling classes. It was scientific invention that brought about the abolition of slavery.

In our own day, once again a social revolution is preparing which is rooted in a similar cause, namely, the invention of the automatically operated mass-production type of machine which in a few minutes and at negligible cost can produce a precise and complicated product such as the engine of a motor car, the manufacture of which by the hand labour of a skilled artisan would take at least a hundred times as long and cost hundreds of times as much. This replacement of the individual worker by the machine has undoubtedly created a social and industrial problem just as serious as that which arose when slave labour was first put into competition with power-driven machinery. On this difficult problem I may have a few remarks to offer in a later article.