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Science and People

HISTORY IS THE STORY of great discoveries and great inventions. These make the human scene an exciting one. Science seems more fantastic than fiction.

Some persons are challenged by the mysteries of the moon and stars; some by the mysteries of the atoms; others by the mysteries of living things, including themselves. Seldom do we come upon a person who is not, at some time or another, interested in one of these mysteries, a person who does not feel the challenge of the unknown.

To the scientist anything that is unknown is important. Science is an imaginative and exploratory activity. It is also critical and analytical. The scientist requires evidence before delivering an opinion. He is impersonal and dispassionate.

Critical thinking is an important aspect of the scientific attitude. In solving a problem we need to ravel out some of the contributing factors and work with those we can control. Science consists of a body of related and verifiable statements of the type: "if . . . . . then . . . . ." All discoveries of truth in science are reached by people going around the new truths in ever-narrowing circles, drawing nearer and nearer to them, until some bold and gifted person seizes the very centre of the new truth and makes it visible to everyone.

There are people who credit all scientific discoveries to chance and accident. The truth is far otherwise. Discoveries are made by scientists who observe an unexpected phenomenon, an inexplicable result, an impossible occurrence. That is, to them, a pointing finger, and they plunge into research to find the why and the how and the meaning.

Methods of science

A scientist may not be the first person ever to see a curious phenomenon, but he is the first to *observe* it. He looked twice at an unusual occurrence, was dissatisfied with his inability to account for it, and sought persistently for an explanation. People in business can with profit follow his lead: observe coolly, analyse without emotion, collect the evidence and examine it critically.

The scientist seeks to see things together so that he may make comparisons. He develops skill in turning to profitable account previously undetected relationships among the things and conditions in his environment.

Physical science rests upon verified hypotheses. In science, truthfulness is an essential condition for success. What was true yesterday may not be true today, or only partly true. The truth of Aristotle was replaced by the truth of Newton which was replaced by the truth of Einstein. A scientist is not interested in finding something that is popular, or that fits in with his ideas, but only in finding out what is true.

It is well for everyone, in whatever line of work he may be engaged, to apply detailed analysis to wholesale or hypothetical assertions, and to substitute specific inquiry for temperamental convictions, and to prefer a small new fact to a cloud of opinion.

Research is work

Non-scientists tend to believe that a laboratory is swarming with eye-popping discoveries every week, but no knowledge is gained and no theory is developed without a great deal of labour. Both the "pure" scientist and the "applied" scientist work arduously.

Theoretical research seeks to know things better; applied research seeks to learn how to do things better. In one case knowledge is sought for her own sake; in the other case the desire is to find ways of applying a newly discovered fact or theory to solution of practical problems.

Research workers in pure science are vastly enlarging our field of knowledge. In John Milton's memorable words they are "still searching what we know not by what we know, still closing up truth to truth as we find it."

Asking questions

Aristotle, son of a physician at the court of King Philip of Macedon, organized the first scientific inquiry in the world. He was so curious about nature that he had a thousand men collecting material for his natural history.

What would happen in Canada if every person started collecting specimens and asking questions about things that they have up to now taken for granted? These two activities led to the great advances in scientific discovery and understanding. The twilight zone between what we know and the vast range of what we do not know presents us with innumerable frontiers for exploration.

Scientific exploration has some of the attributes of good housekeeping. To be a good scientist you need to have a tidy mind that keeps thoughts and facts in their proper place; you must discriminate so as to discern what evidence should be accepted and to discard what is irrelevant; you have to pay attention to small details in your research to prevent something vital from slipping away unnoticed; you are called upon to recover quickly after your work has been interrupted; you need to keep an eye on what your neighbours are doing in the way of finding out and doing new things.

The most valuable of all the perceptions we use in scientific research is the perception of cause and effect. This is the most important natural law that we have. Too often we say "in the beginning" and imagine that we have pinned down a vital point from which everything else follows. But before long we find ourselves asking: "what was there before the beginning to make it possible for the beginning to begin?"

Insofar as science accepts the principle of causality, and inasmuch as the universe cannot be self-caused, we are led inevitably to the conclusion that there must be a causal factor not comprised within our present view of the universe. Thomas Aquinas put this principle in a nutshell: "No thing is its own cause, for then it would precede itself, which is impossible."

Science and progress

Science is one field in which progress should be measured and given credit. We should not withhold praise from famous men and women of the past because their concepts have been outdated: our important duty is to improve on what they did.

Scientists and inventors do not work in vain, even though the products of their minds may be superseded. Consider Newton and Icarus. Newton has been acknowledged as the greatest scientist in history: he discovered the law of gravitation, the laws of motion, the principles of optics, the composite nature of light, and with Leibnitz he invented the calculus.

There is not, however, any concept of the Newtonian physics, believed at one time to be the whole truth, that has not been displaced. As Professor Alfred North Whitehead remarked: "The Newtonian ideas are still useful, as useful as they ever were, but they are no longer true in the sense in which I was taught that they were true."

Icarus, whose airplane wings fell off and dropped him into the sea when the heat of the sun melted the wax that fastened them together, performed a useful service. Sir Arthur Eddington said: "I prefer to think of him as the man who brought to light a serious constructional defect in the flying machines of his day."

The first crude microscope was focused on the hidden minutiae of life by the Dutch microscopist Leeuwenhoek, in the 17th century. Three men, Professor E. F. Burton of Toronto University, James Hillier and Albert Prebus, produced the electron microscope in 1936 opening up a whole new world to investigation. Roger Bacon discovered the explosive possibilities in a combination of saltpetre, sulphur and charcoal and produced gunpowder in the 13th century: the present century saw the birth of the atom bomb.

These are fragments extracted from the score-sheet of science, typical of thousands of discoveries and developments that have contributed, alone or with improvement, to the advancement of human beings in peace and in war.

Important advances

Nobody can deny that science and invention have raised mankind to a higher material level than the one occupied a hundred years ago. They have increased the output of work per man-hour, so that we are able to cope in some measure with the increased demands of a greatly enlarged population. Science has added to the kinds of products that cater to our comfort. It has increased the number of occupations at which men and women may work.

Two of the greatest advances of our age are the production of drugs like penicillin, insulin and sulpha, which have prolonged our lives by many years, and labour-saving machinery which has made work easier and provided more leisure.

What really constitutes a high standard of living? Fundamentally, nutrition, literacy and health. Science has given these to people in the developed nations, and they are being extended, though slowly, to the developing peoples of the world.

Science and technology change not only our material environment but our institutions, and this is a good reason for everyone to keep up with what is happening, to learn about, or try to anticipate, the social implications of scientific discoveries and attainments. Every newly discovered process and every invention has brought with it unpredictable uses, created new obstacles to be overcome, and uncovered new problems and frustrations to be resolved.

The discoveries of science cannot be put to practical use without the services of the technologist. He makes inventions by interpreting something, adding or taking away or dividing or multiplying something. Every invention that proves useful stimulates further scientific studies which lead to improvements and to more inventions.

Of course, everything that is invented is not a memorable addition to our lives. Nearly everyone has said at least once: "Necessity is the mother of invention" but it remained for Herbert A. Leggett, Vice-President of the Valley National Bank in Arizona, to say in one of his monthly letters: "We live in an era when invention is mother of the unnecessary."

Automation is the technological revolution of the second half of the 20th century, just as mass production was of the first half. The late Norbert Wiener, distinguished mathematician of Massachusetts Institute of Technology, did much of the conceptual thinking that underlies the new technology. He predicted that automation will lead to the "the human use of human beings"; that we shall experience a phasing-out of the type of factory labour that is engaged in performing repetitive tasks. This will release men and women to use their specifically human qualities — their ability to think, to analyse, to synthesize, to decide and act purposefully — instead of wasting their talents on the dreary work that machines can do better.

The application of energy

The development of energy is not a new process and a new problem. James Watt improved the steam engine made by Thomas Newcomen and Richard Trevithick adapted the engine to transport. No one on the platform at Darlington on the day the first railway was opened for traffic would have dared to predict that 150 years later, in October 1974, the pulling of freight cars along a track would have progressed to the point that a train two and a half miles long, with seven diesel locomotives, the successors of steam, would carry grain from Moose Jaw, Saskatchewan to Thunder Bay, Ontario.

In physics, an outstanding event was the publication of William Gilbert's *De Magnete* in 1600, introducing the word "electricity" for the first time.

The simple phenomena associated with static electricity, such as sparks from rubbing a cat's fur, were known for 2,000 years before systematic research was undertaken. Lady Dufferin, wife of Canada's Governor General, tells us in *My Canadian Journal* (Longmans Canada Ltd., 1969, edited by Gladys Chantler Walker): "February 28, 1874. I held a piece of wire, or a needle, in my hand, rubbed my feet on the carpet, and touched the [gas] burner; a spark was emitted, and the gas instantly blazed up."

Electricity was first turned on for the regular supply of light in New York on September 4, 1882. Had it not been for an armed revolt, that ceremony might have taken place in Canada. Thomas Edison's father, Samuel, who was born in Digby, Nova Scotia, married Nancy Elliott, a teacher in the high school in Vienna, Ontario. He became a captain of William Lyon MacKenzie's insurgents, and when the rebellion of 1837 failed he fled across the border. Thomas was born in Milan, Ohio, on February 11, 1847.

To non-scientists, "electronics" often suggests vague impressions resembling science fiction and mysterious invisible power. "An electron is a rare bird whose behaviour is unpredictable," said Whitehead. "Our information about electrons mostly concerns flocks, numbering millions."

Sir J. J. Thomson showed that the cathode rays produced by an electric discharge in a vacuum tube are really streams of particles thousands of times smaller than atoms. Electronic vacuum tubes had just reached the height of their importance when a new discovery led to the development of the transistor, and the field of solid-state electronics came into existence.

In these days of electronic checking of passengers boarding airplanes to detect potential hijackers it is interesting to recall that the Moon Gate of the imperial palace near Peiping, China, built 2,300 years ago, was made of solid lodestone, a magnetic iron ore. This was done to prevent assassins from entering the imperial residence carrying weapons concealed in their clothing.

Splitting the atom

Then we split the atom, or, in the more scholarly language of Sir James Jeans: "Thanks mainly to the researches of [Sir Ernest] Rutherford, it has now been established that every atom is built up entirely of negatively charged electrons, and of positively charged particles called protons. ... With one turn of the kaleidoscope all the sciences which deal with the properties and structure of matter have become ramifications of the single science of electricity."

The credit of the first definite proof of atomic transformation belongs to McGill University, Montreal, where Ernest Rutherford, the greatest of all nuclear physicists, came in 1898 (the same year that Marie Curie discovered radium) to a post in the Macdonald Laboratory.

In 1903, at McGill, he wrote in his book *Radioactivity:* "There is reason to believe that an enormous store of latent energy is resident in the atoms of radioactive elements. If it were ever possible to control at will the rate of disintegration of the radio-elements, an enormous amount of energy could be obtained from a small quantity of matter." In 1911 Rutherford announced his nuclear theory.

Albert Einstein entered the scene in 1905 with discoveries that have had the most profound and direct effect on the present-day world. The release of the tremendous force of atomic energy could be achieved, he said, according to a formula which he offered, the most important equation in history: $E = mc^2$. The utter destruction of civilization lay within its possibilities. Einstein estimated that in an all-out atomic world war, with both sides thoroughly equipped, two-thirds of all mankind might be slaughtered.

In face of this melancholy possibility people as a rule pass over the more laudable peaceful uses of atomic energy. In a controlled chain reaction, the atom can be made to give up its vast store of energy slowly and usefully, to drive a steam turbine, to produce electricity, to purify sea water, to preserve food, to facilitate research in biology, to treat diseases, and in a hundred other ways.

The place of mathematics

Mathematics is referred to as "the queen of sciences" because it enters into and governs almost every other department of knowledge. It is the systematic treatment of magnitude, relationships between figures and forms, and relations between quantities expressed symbolically. Plato wrote that among all the liberal arts and contemplative sciences the science of numbering is supreme. Asked why man is the wisest of animals, he replied "because he knows how to count."

Euclid, the first professor of geometry in the university of Alexandria, wrote a textbook called *Elements of Geometry* which has shown great staying power. It has remained in service for twenty centuries. Its thirteen books represent one of the greatest intellectual achievements of mankind.

It has been said that more new mathematics has been created during the past fifty years than in the whole previous history of the human race. The gap between the old and the new mathematics fathomed by creative mathematicians has widened rapidly.

From abacus to computer is a long jump. The abacus is a frame set with rods on which balls or beads are moved by hand in the process of calculating. The computer is a mechanical or electronic apparatus capable of carrying out highly complex mathematical operations at high speed.

The other sciences have moved ahead with similarly impressive speed. At the beginning of this century one was likely to be told "The universe is a spider's web of vibrations on which the fire-flies of stars and atoms hang trembling." That was pretty poetry, but we like to be more specific today, and so we consult observatories like the one on Mount Palomar in California. Its 200-inch telescope has a range taking in about a thousand million galaxies.

The biological sciences are not, as some people suppose, merely utilities in medicine and agriculture. The diversity in structure and habit of living things is remarkable, and this variety gives biology a richness in special problems. Nearly two million different species of animals, of which half are insects, have been scientifically described and named. The biologists are helping mankind to continue to preserve its existence in an increasingly distorted environment.

Medicine, the art of understanding diseases and preventing them or curing them or relieving them is of interest to every person. Medical research has given great benefits to mankind.

Between 3000 and 2000 B.C. a doctor-priest in Egypt set down a detailed record of cases he considered worthy of preservation. There, for the first time so far as we know, man started to rear the foundation of true medical science. Medicine today has entered the microfilm age where knowledge is so vast and changing that it can no longer be bound within the confines of one single cranium.

Genetics, the study of heredity, has been combined with the study of mutations to form a science of impressive stature. In 1900 the laws of heredity, stated by the Abbé Mendel in 1865, were rediscovered and established.

Anthropology is the scientific study of the physical, social and cultural development and behaviour of human beings since their appearance on earth. It traces the rise and development of civilization.

Geology is logic applied to explaining the formation of the earth's crust. Besides its undoubted academic interest, geology is prominent in the practical affairs of life, as, for example, the energy crisis. Nature's operations in laying down the world's mineral deposits have been proceeding over a span of probably two billion years. In one century of active exploitation man has dug well down toward the bottom of some of the mineral bins.

We have not yet solved conservation problems. While analysing more closely than we did up to a few years ago the condition of stocks and operating results, all we have succeeded in doing is to keep two swift running paces ahead of the grim accountant.

Every person who has reached the scientific stage of development — and resource conservationists are among them — realizes that success in living does not depend upon coaxing or forcing nature to do what we want. It depends upon understanding nature's laws, and in making use of them to serve human purposes in perpetuity.

In everyday life

Many people are apprehensive about changes they see in their environment and in their customary way of living. It is well to remember, when thinking of changes in the future, that enormous changes have taken place in the past.

We need to think of change as part of the process of living; to prepare for it, to accept it, and to make the best of it. We cannot simply be: we must become.

Many point out that man's spiritual development has not kept pace with his material progress. "This is obviously true," said George Russell Harrison in his book *Atoms in Action*, "but blame for the situation can as justly be attached to the slowness of spiritual development as to the rapidity of material progress."

We are moving toward unknown horizons. The scientist knows that the great art of research lies less in solving problems than in discovering problems to be solved. Most research people dwell in the present only long enough to finish a job: thereafter their minds leap into the future.

This is a strange and wonderful universe whose ultimate secrets we may never quite confine within a scientific equation, but it is nevertheless interesting and beneficial to learn as much about them as we can.

