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of science on society

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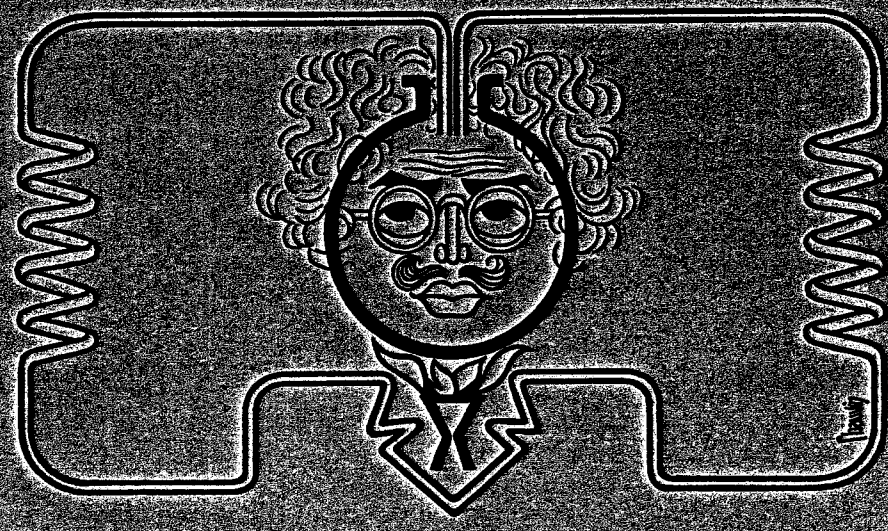

Nobelists muse about science

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AN INVITATION TO READERS

Reasoned letters which comment, pro or con, on any of the articles printed in *Impact* or which present the writer's view on any subject discussed in *Impact* are welcomed. They should be addressed to the Editor, *Impact of Science on Society*, Unesco, Place de Fontenoy, 75700 Paris (France).

Scientific progress and the human condition

by Giulio Natta[1]

Contrary to common belief, social and political developments have not been the germ of scientific and technical change. The opposite is true. The Industrial Revolution and its social significance have led us to the present era of petroleum and nuclear energy exploitation. Our use of these resources affects our very life cycle, the consequences of which we still appreciate inadequately. Continuing research and new research are vital to our welfare, and must go on.

I am asked to express my views on 'the relationship between science and society', and it can be done to a large extent by answering two questions running something like this:

What relationship exists between scientific discoveries and the history of human progress?

What is the part played by the scientist in the various activities of mankind?

The history of mankind seems to me essentially the history of scientific developments and indeed the story of man in the most distant ages is systematized in terms of scientific discoveries. The Stone Age, the Bronze Age, and the Iron Age are simply major historical divisions named for the corresponding inventions.

The human events traditionally dealt with by historians, the alternations of social organizations, wars, the rise and decadence of peoples, are subjects which loom large if examined with a sufficiently brief historical interval but become negligible viewed in a later temporal frame of reference.

In the most remote epochs of human history, what is remembered is not the vicissitudes of the various tribes but their productive capacity, the progressive

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knowledge of the different metals they used, and hence their technico-scientific development.

SCIENTIFIC DEVELOPMENTS CAUSE SOCIETY TO EVOLVE

Very frequently, however, scientific progress is regarded as the outcome of particular political and social situations. This may be true to a limited degree, but in reality it is the reverse that happens. For example, it was not a matter of the French Revolution transforming Europe from an agricultural to an industrial society, and so starting the great technological and scientific development of the last two centuries, but the scientific discoveries of previous centuries—by creating new kinds of activity and hence new classes of craftsmen and manufacturers—overthrowing the old magnate whose power was based on the ownership of farming land.

Naturally science, like all other human activities, is profoundly influenced, especially in the choice of its most immediate objectives, by the policy of the society in which it operates, but the results it arrives at are generally of an importance extending far beyond the original objective. Thus, in Germany at the time of the First World War, the British maritime blockade made it very difficult to get supplies of the nitrates which were the raw material for making nitric acid, and hence, explosives.

This greatly stimulated research on the synthesis of ammonia from nitrogen and hydrogen, which could easily be oxidized to nitric acid. The research was successful and the desired results obtained: being able to manufacture explosives without importing nitrates.

The effects of the synthesis of ammonia were, however, of great diversity and of considerably greater importance. Ammonia and its derivatives are, in fact, the components of the greater part of the chemical fertilizers which have led to a tremendous increase in agricultural yield and so have made it possible for the same area of land to feed a much bigger population. Today, the amount of ammonia used for war materials is negligible in comparison to the quantities used in agriculture.

DISCOVERING RESOURCES AND HOW TO USE THEM

A scientific discovery originally applied to war purposes, but which will probably give its name to an age which has scarcely begun, is nuclear power. This is a further example of how the discovery of a resource and the study of how it can be exploited may produce new eras in the history of mankind.

At the present time, our civilization is based on the exploitation of petroleum, from which we get power, plastics, textile fibres, food and almost the whole range of raw materials by organic synthesis. Nuclear power is slowly replacing petroleum as a source of energy and will probably leave it only the more noble use as a source of organic products for chemical, textile and alimentary purposes.

This will permit an increase in world population without a reduction in the means available to each individual. I do

not know how that population will be organized socially but, unfailingly, social changes will always be determined by the new situations created by scientific and technical development.

Very often this fundamental influence of science on the history of mankind is interpreted adversely. For example, a very tropical and much publicized problem is that of pollution—an accumulation of solid, liquid and gaseous wastes. It is an indirect consequence of scientific development, but more directly due to the increase of population and its way of life. To grasp the mechanism of this phenomenon, we must bear in mind that the biological world consists of a series of beings (animals, plants, micro-organisms) which live on each other's wastes.

CARBON DIOXIDE IN THE LIFE CYCLE

To take an instance, one of the things on which plants live is the carbon dioxide which men and animals eliminate by respiration. We in turn feed on the plants and animals which feed on vegetation. This is a very brief cycle, but there are others longer and more complex. In the present century new factors have arisen: mankind has increased in numbers and each individual consumes more. A person who travels by car and lives in a heated house produces, by burning fuel, a quantity of carbon dioxide immensely greater than that eliminated in his breath. The carbon dioxide is then rapidly assimilated by plants.

On the other hand, there are cases where the utilization of waste matter by other biological elements is slower. Some elimination is not by biological, but by chemico-physical processes. The result is an accumulation of matter (non-biodegradable polymers, some chemical compounds, or inorganic materials) which may have an adverse effect on the biological cycle.

The problem is already being dealt with in many countries and by the end of the present century it is likely to be practically solved, at any rate as far as the most important aspects are concerned. Among the many solutions, a widespread and economical one is the recovery of waste products, i.e. their conversion into other useful products and into energy by combustion.

I do not believe in the deleterious effects of scientific progress which are sometimes predicted, although I realize that we are living in an age with no previous analogue in history for the importance and number of scientific discoveries concentrated in a very brief space of time.

THE INFORMATION DYNAMICS OF SCIENTIFIC RESEARCH

I now come to the second question, that is, what is the role of the scientist in contemporary society. For simplicity's sake, I apply the term of scientist solely to those who seek something new via experimental method. The research may take place in the most varied fields, even fields very different to those traditionally called scientific. At the present time scientists are pursuing their work in very narrow fields, a consequence of the fact that those who are looking for something new must

be acquainted with all that has been done before. Currently this is possible only by severely restricting the field of research, a trend which is increasing noticeably.

When I was young it was possible for a chemist to be familiar with the entire range of chemistry and physics, and I personally worked on a wide diversity of subjects. About 1920, when I was an undergraduate, I made myself an X-ray diffractometer and worked on crystallography. When I had graduated, I planned and built, with no model, an apparatus for the synthesis of methanol. Thereafter I went on to oxo reactions, polymerization, and molecular structures.

The succeeding generation, that of my former assistants, is much more specialized. Some are concerned with polymerization processes, others with chemical engineering, others with industrial chemistry, and still others with molecular structures. Their assistants work in still more limited fields. Specialization is essential, but there is the danger of much useful information being lost through the obstacle of communication between disciplines. The difficulty is increased by the fact that each discipline tends to evolve a terminology which is convenient, but highly specialized, to the point of being barely comprehensible to other disciplines.

As a consequence of the high degree of specialization and of the need to use a variety of techniques in scientific research, this activity which has been organized essentially on workshop lines (a one-man or small partnership job) is now becoming an industrial operation requiring carefully organized teams, sometimes comprising a large number of researchers.

THE BETTER AND THE BEST OF SCIENCE AND TECHNOLOGY

These teams, if efficient, are liable to produce a tremendous mass of scientific work It may be asked if the many thousand of people engaged in organized scientific research are all scientists. In a certain sense they are, though very few will leave a noticeable mark on the history of science: I should say a few dozen per century That may seem very little but, if we look into the numbers of great artists, great generals, great statesmen, we find that once again they are very few in number too.

The new ideas of these few individuals represent the successive steps in the progress of science, and consequently of human society. I think that the influence of these few on history is very great greater than that of those eminent statesmen and generals, although it may not be evident—given the difficulty inherent in examining sufficiently lengthy periods of historical time.

Thus it can be asked what would have happened if some of these leaders had been missing. If Newton, the father of modern mechanics, had never existed would the history of mankind have been different? Probably not, but it is likely that it would have been held back somewhat while waiting for another man of uncommon genius to discover the fundamental laws of mechanics.

Another function of progress is to increase its own future possibility, that is, to identify subsequent developments fields destined to yield other advances The phenomenon is self-incremental, so that considerable change can be antic

pated in other scientific and technical fields which will open themselves to coming generations.

Research is unquestionably fascinating in the extreme, and anyone pursuing it can well be drawn towards ever newer lines of inquiry. If I had to begin again, I would still devote my life to research.

SUGGESTIONS FOR FURTHER READING

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