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SCIENCE AND SOCIAL PIONEERING[1]

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THE classic tale has man witless until he receives the Promethean gift of fire. Light and fire are the age-old symbols of the mystery of the creative force in man or of what some would call the divine beginnings of man's discovery of a forward way. We talk less of mystery to-day for, if the source of the light of understanding is still unknown, man himself has successfully trimmed the wick. Reflected, dispersed and recombined from thousands of mental and spiritual facets, the light reveals ever-new possibilities of adventure, experiment and stimulating insight for the self-conscious creature, half angel, half brute, who talks endlessly about his elusive destiny. Whatever their own genius may be, all thoughtful persons borrow or reflect enlightening fact wherever they find it, and observe with alternating hope and anxiety the endless search by other men for that object of faith and labor called progress.

Reflecting in this fashion, it seemed to me presumptuous to express only my limited individual opinion in this opening address in an annual exchange between the British and the American Associations for the Advancement of Science. It seemed better to inquire of others what they would choose to say. Because scientists are apt to praise the children of their brains, the views of non-scientists were sought on the contribution of science to social welfare and to that uniquely human process of consciously planned advance across the threshold of experience which we may call social pioneering.

To that end I invited one hundred men who are not engaged in either physical or biological research or teaching to express their opinions. For special rea-

[1] The first British and American Association Lecture, Dundee meeting, 1939.

sons two exceptions were made. The opinions are almost wholly American; I have included those of but a few English and French friends. The list includes lawyers, teachers, artists, poets, government officials, historians, economists, preachers, industrialists, left-wing and right-wing publicists, military men, bankers and railway executives, as well as a member of the United States Supreme Court, a member of the President's Cabinet, public institutions of many kinds, men with power of command over others and men who exercise power only through ideas. With few exceptions they are men whose names are well known on both sides of the Atlantic.

Each person was asked to set down not his studied or rationalized opinion, but rather his quick and customary response to the idea that science has or has not added to man's cultural possibilities, given him a better way of thinking through his difficulties, raised his hopes for a more ethical civilization. Was his *habitual mode of thought* with respect to these propositions positive or negative?

To keep my promise to contributors the following twenty numbered statements, which combine the one hundred opinions, are given without references to sources. They are arranged in three groups—those which emphasize the gains (12), those which express qualified approval (5), and those which point to losses (3). No attempt has been made to give them consistency (compare, for example, items 10 and 5).

Emphasizing the Gains

(1) Science is to-day the most excited front of human enterprise, and such excitement is a good in itself. The fact that tens of millions of people are interested in scientific discovery and theory is one of the hopeful things in this Pandora's box of a time. Conceivably these tens of millions are or might become interested in a wider view of human affairs.

(2) The light that science has thrown on religion has made the difference between fearing God and believing in God, for it brings God within the sphere of personal experience. It has done this mainly through the removal of the fear of the supernatural. It has not lessened the force of religion by weakening the force of orthodox religion. There is neither an Acheron nor a seat of torture of souls: the shades are peaceful abodes.

(3) Science has enabled us to understand many catastrophic forces though we control or combat, with limited success, but a few. Thereby it has reduced the areas and much of the strain of ignorance, superstition and myth. Forecast in several fields has entered so effectively into civilized man's thinking that it tends to stabilize both mind and act to a remarkable degree, giving a sense of permanence or at least assurance in the midst of obvious change. We no longer cower before "the forces of nature," at least intellectually.

(4) Science has encouraged specialization, and specialized knowledge is the mother of invention. Both have greatly complicated life by making us all increasingly interdependent. In the past half century a multitude of new occupations has grown up employing millions whose livelihood is dependent upon multiplied wants and the complexities of specialization and interchange that feed them. Science and invention, and commerce between the less civilized and the more civilized peoples, have encouraged a phenomenal increase in world population. "Back to the simple life" would mean starvation for many of these millions: it would also mean additional manual toil for almost all of us as well as diminished comfort and security. There can be no *Erewhon*.

(5) Science serves an expanding civilization, but we do not know anything at all about our ultimate fate: the future is beyond conjecture: "the end is forbidden." If science has introduced dangers it has also made a net addition to human welfare by greatly expanding man's identification and use of natural resources. Humboldt's dream of "enlarging the outlook of mankind" through geographical study has been realized: the diversities of the earth have enriched life immeasurably. Synthetic chemistry has supplied a host of new products and opened gateways to still wider conquests afield. Like animal and plant breeding, it has changed the human potentiality in, and therefore the significance of, large parts of the natural environment. It has not destroyed geographical diversity, but it has become a factor in the rearrangement and revaluation of diversified resources.

(6) Science insists that *facts* are indispensable in the ordering of social change or reform. Though we proceed by trial and error to a large extent, it is science, especially the analytical use of statistics in the social field, that ruthlessly exposes error and helps to restrict the areas of prejudice and uninformed preconception. Sentiment and emotion have their place in the evolution of society from lower to higher, but in themselves they are fallacious guides. Social programs are put forward as tentatives or hypotheses if the scientific method is followed. In earlier times one could give categorical answers to all questions of objective and meaning. Science has eliminated much of the categorical.

(7) The effect of the doctrine of evolution upon modern thought in many fields has come to be incalculably great. It has revealed a far more complex universe than had been conceived under the assumptions of fixed numbers and kinds of species that in turn accorded with the simplicities of the geometry and the idealized astronomy of the Greek climax. It destroyed in time the over-generalized doctrine of universals in

nature. It weakened the hold of metaphysics upon observational significances. It showed up the limitations of abstract logic in discovering or assimilating truth that is either essentially irrational or subject to change as new facts emerge and men are driven to make "a fresh examination of particulars," as Francis Bacon phrased it. It gave new meanings to both science and society by its revelation of a body of knowledge that drew its ordering from the historical record of the origins and evolutions of types correlated with the geological time-scale on the one hand and with experimental results on the other.

(8) Many of our social problems are ethical, and in this respect the common man is perhaps the equal of the intellectual in balance, temperament and insight, or even surpasses the insulated and stylized man who has the protective walls of an institution around him or the assurances of recognized social position or wealth. In these days of exaggeration, when mere political mechanisms tend to be worshipped as golden calves, the scientist at least knows that there is no collective salvation of souls and no final order. It is the business of science to discover truth, not salvation. In many instances salvation comes through the emotions and they are generally inaccessible to reason: it is also in large part an inner process, as Mazzini observed: "You will not have things better until you are better yourselves."

(9) Historically, the indebtedness of economic study to natural science is two-fold: replacement of the naïve premises of classical deduction by positive data and the use of such data in facilitating the much-neglected but indispensable step in economic deduction, namely, verification. The methods and objectives of political science have been re-examined under the inspiration of scientific influence. A healthy inconoclasm has ensued and the positive approach has become dominant. Historical writing has come to have greater accuracy and objectivity, less emotion, prejudice and prepossession, and more convincing conclusions, but might not these qualities have been gained without the example of science?

(10) Public health has been promoted by progress in biology and biochemistry and by public acceptance of or demand for appropriate administrative measures. Out of the disaster of the Asiatic cholera in the thirties of the last century arose the office of Registrar-General in England over which William Farr presided for a time. Concerning that event Dr. Parkes, an English hygienist, wrote: "It is impossible for any nation, or for any government, to remain indifferent when in figures which admit of no denial, the *national amount of health and happiness, or disease and suffering, is determined* (our italics). The establishment of the Registrar-General's office in 1838 and the commencement of the system of accurately recording births and deaths will hereafter be found to be, as far as the happiness of the people is concerned, one of the most important events of our time." During a discussion in Parliament in 1875 on the Public Health Act, described as the most complete code of sanitary law in existence, Disraeli said: "The public health is the foundation on which repose the happiness of the people and the power of a country. The care of the public health is the first duty of a statesman."

(11) The scientific attitude of mind is indispensable to further social progress, but scientists should be more modest in their claims. However closely one investigates and measures there is always a gap at the end to be jumped by the imagination. The gap can be narrowed considerably by careful thought, but after that one wants just knack or nose. Truth is deep down, said Democritus. In social applications of science one should be mindful of the precipitate of human experience which tradition represents as well as of the conflicting solutions and assumptions which we have inherited. Science itself does not supply adequate motivation for dedicated and unselfish living, living on a high level. If a scientist has these qualities it is because he is something more than just a scientist. Science has given a vast number of material satisfactions, but where has it left public thinking with respect to the heroic struggle without which a people has no fiber, no victory?

(12) Humanitarianism and democracy stand in the way of wider applications of science to social problems: they have permitted an enormous increase of population, with a rising proportion of biologically unfit and a rising standard of care for the unfit. Civilization may be too much for *Homo sapiens*, but at least we keep on trying, and science is one of the ways of trying. At times the growth of large corporations has also stood in the way of wholesome social change. In the absence of any clear philosophy of control by society they grow past the bounds of public knowledge. While they have had well-known beneficial effects they also permit a modern form of ruthless raiding. A democracy is required that not only gives economic and political opportunity but also treats men as ethical and spiritual beings.

QUALIFIED APPROVAL

(13) Science, largely by its emphasis upon the freest and widest inquiry, has aided in the diffusion and acceptance of the principle of religious and racial toleration, but there is grave doubt of the strength and permanence of this gain.

(14) Lord Kelvin's remark that "you do not know much about a subject until you have tried to measure it" is clearly applicable only to that which can be measured. Science deals quantitatively with measurable material things and less with *quality* which sup-

plies the essence of culture. With its emphasis upon a mechanistic theory of inevitable law, science has acquired a prestige that can be a real danger. The crucial question is, what has science done to enable the individual to *see* the pattern of his ideal more clearly and to *fulfil* his new vision? Measurement and accuracy do not touch even the fringe of social questions. The totality of human affairs (ideas, beliefs, conduct, habits, institutions, etc.) can not be reduced to deterministic sequences. Knowledge of facts does not tell us what to do about them. *Social action is based upon assumptions, expressed or implied, respecting human values.* Science helps indispensably, however, in its zest for truth, for careful observation, for an even-tempered attitude.

(15) Science has shrunk the planet, close-knitted civilization, and practically revolutionized life. Once we thought it remarkable that *news* from all over the world got to us each morning; now the distant trouble itself is at our door. While our curiosity has been widened, will any one claim that our sense of responsibility has been enlarged? Are we usefully informed or only distracted? A high degree of accuracy has been attained by news services if methods and time limitations are taken into account, with the result that "public opinion" has gained a status not unlike that of a world conscience. The dictators always lay hands first upon radio, cable and newspaper. They wish the rest of the world to be unaware! Two chief difficulties delay the realization of a better international order: (1) the increasing dependence of individual welfare upon a limitlessly expanding number of other individuals unknown to him as persons; and (2) the creation of an unbelievably complex web of human ordering beyond our present means of guidance.

(16) Very few people know anything about or care about science in a fundamental sense. The better a product becomes and the more widely it is used the less public interest is shown in its origins and mechanism. It is the esthetic factor that now counts most in a motor-car: all cars run well. The public will continue to accept the findings of science but, if pushed too fast in the direction of new social schemes called "scientific," they will become frightened. Our time span for social change is now much shorter than formerly. In an earlier day more time was given to absorb change without conscious direction. Hair-trigger thinking is now fashionable in the social field, with action but an instant behind, and the revisionary habit of science applied to such thinking would have a desirable sobering effect. At present, applications are left to mediocre minds. Shamefully little progress is made towards the solution of basic social problems such as housing, access to medical care, stabilization of employment.

(17) Universal education offers the only hope of establishing in the minds of the people the minimum conclusions of science that bear on social welfare most directly, or appear to do so. These minimum conclusions can become the blueprint of social engineering only if they are kept within the range of mass thinking. That range, in turn, is limited because human desires are dynamic and simple, while human intellect is telic and complex. Desires propel, intellect can only feebly guide. "People" see the *things* of science and forget the *discipline*. Their minds are littered by ideological concepts and dogmas, incapable of verification, that stand in the way of acceptance of a scientific approach to social problems.

Losses

(18) We live in "the dark hour of a gifted age." Science has made war more terrible; it has debased mankind by its growing disregard for helpless and innocent non-combatants; it has forced the whole of civilization to adopt the most horrible methods of destruction. Men have tried to agree not to use the worst instruments of warfare, as the Church once tried (1139) to anathematize the use of "the deadly and hateful art of crossbowmen and archers in wars against Christians and catholics"; but in the end each new frightfulness triumphed.

(19) It is a clever, cynical and hard-bitten world that science is making, one in which the idealistic and the spiritual are bound to have a diminishing place. Viewed against a background of classical education science has been a disadvantage to our society. If the most important questions of mankind are those concerning spiritual relations with one another and with God, then science is not to be taken seriously. Through dazzling discovery and successful practical application science gives a sense of power that is both demoralizing and dangerous. We are given an enormous driving force that does not permit us to be as bad or as foolish as we could be with impunity down to the middle of the eighteenth century. The impact of science on our morality, individual and national, is evil unless we rise successfully to the test of our character and moral traditions. Science has taught us analysis, but we have had as yet no large-scale and equally successful synthetic constructions that bear on human conduct. The mass mind seizes and acts upon perverted ideas of scientific generalization. Darwin's "survival of the fittest" encourages men to be brutal; Freud's "don't repress," to indulge their passions; Einstein's "relativity," to think that truth doesn't exist and doesn't matter.

(20) The fickle wishes and caprices of men, in economics and government particularly, have been given weight and apparent rationality by the adoption of unsuitable methods devised by technocrats accustomed to weighing material objects. To limit oneself to

"data" in social studies is to parody society. Human science must think of life as a whole. The riddle of life is not in objects or discoveries without, but in conscience and mind within. A man's "destiny" is what he can make out of his own character.

"SCIENCE" IS NOT A UNIVERSAL

In weighing these responsive observations one does well to keep in mind that what we call "science" is largely though by no means wholly a conscious intensification of methods and results that had exceedingly remote origins. Science is a part of human life, not something separate and distinct. Farmers of all centuries, fishermen and especially sailing folk—all have developed science of a sort: empirical observation, limited analysis and generalization, confrontation of theory (idea) with fact, as well as revision or modification (with much myth and nonsense built in too). The methods were not labelled or systematized, cause and effect were often wrongly ascribed, but the result was progress by taking thought.

It does no good to vaunt science as if it were something that stood above the rest of knowledge—independent, self-sufficient, worshipful. As human experience, science is not a universal, a summation of knowledge applicable and useful to the whole of life; it is rather a thing of limited categories. Science gains nothing by the decline of humanism: it is itself a special form of humanism. One asks, what is its net worth in the sum of human interests? What does it add to education, to outlook, to citizenship? And especially what does it add to human possibilities, to spiritual incandescence?

No claim for science may be set up without pointing to the limitations of scientists as individuals in responding to prejudice, group opinion, and the like. To most scientists, science is only a specialized form of experience. When a scientific man turns to the social framework which contains his science, conditions it, encourages or discourages it, he is bound to take account of other elements of society than his own, other tastes, other judgments of value in life. Individual scientists are often affected by the source of their support. They will tend to approve the policies of the companies that supply them with a living. They will measure a social program by the yardstick of company prosperity. The company may be a profit-making concern or a university.

A scientific career, so-called, does not necessarily make its devotees broadminded, cautious of the word, modest in spirit. It takes more than science to widen a narrow man's sympathies! Science does not in itself "turn the common thoughts of life into gold." Few scientists have the power of persuasive exposition; many have "the gift of infrigidation." Scientists have no monopoly of the power to discard dogma, the courage and intelligence to win territory from superstition. Do they call attention to the merits of scientific method "to protect their banners and slogans" or to improve society?

THE CONCEPT OF CHANGE

In so far as the methods of the physical and natural sciences teach patience, establish the value of both imagination and doubt, enhance analytical power, and provide training in observation, they are of value in any study—crime detection, historical inquiry or the rise of contemporary social movements. But these are not powers newly acquired by scholars in our scientific age. They have always marked all research and insight, in antiquity as in recent times. The poet shares them with the scientist. What biology and geology have done is far more distinctive and new in thought than these qualities denote. They have made the Greek "all flows" not only a matter of time, but also a matter of form and function—change as *the mode of the universe*. How and why things change is at the core of scientific inquiry, not alone how things are.

One of the greatest achievements of science is its emphasis upon free inquiry—the mind itself in command, driven by curiosity and the sense of intellectual adventure. The motive force in an earlier day was faith which removed "not mountains only but the whole material environment." Facts and events were removed from the realm of human action to that of divine grace. Theology and philosophy have since been modified, largely by the light of modern science. Evolution has required every intelligent religion to reshape its view of man. Recent pragmatic philosophy would have little substance if the evolutionary concept were subtracted. After 1860 historical writing clearly showed the effect of the evolutionary approach; and economic theory dealt increasingly with the problems of a dynamic society. The doctrine of evolution involved the minds of men in what can be conservatively described as an overwhelming revolution. In the eighty years since the "Origin of Species" was published no thinking man has escaped its influence.

The concept of evolution influenced some areas of thought long before the modern doctrine of biological evolution was formulated. It was a maxim of Roman law that the limit of the law is its greatest injustice. To codify the law and put it into "tables" represented progress; but it was greater progress to take it out of the tables again, so to speak. Precedents had been proven to be not enough; ethics and public utility were asked to determine forms, and ethics and public utility change with time and circumstance. The whole body of Roman law reflects an effort to apply reason and fairness to a changing society to be accommodated by an elastic set of rules in which the danger of defini-

tions was pointed out. Principles were made to rest on experience; they were "rooted in a philosophic consideration of human life."

In the natural world no such progress was made in Roman times, and indeed we do not see how it was then possible. Lucretius showed what science (as he understood it) could do, but he was unable to make practical proposals for social applications. An understanding of nature would drive fear out of the world, said he, and a better knowledge of both nature and the gods would help bring peace and honor to men. Only as late as our time could the principle of evolution be so variously documented that the idea became accessible and interesting to all men, not the vision of a few. Each specialist came to see fruitful applications in his own field. Dynamic change displaced ideal pattern, fixity and immutability. Lawyer, economist, historian, geographer, priest, chemist and statesman could speak a common language of movement, of continuing adaptation, through nature and through interactive society.

Diversities and Contradictions

Civilization may be usefully considered as an adventure in change. New forces are generated through the evolution of tools, the domestication and subsequent breeding for quality of animals and plants, through age-long folk experiment and through the occupation of new lands with their diversifying possibilities. Each people carries on the adventure in a different way because of its distinctive regional environment, its unique aptitudes and its variant objectives and philosophies.

The diversities of time, place and race may also raise barriers to understanding. Confluent in trade and travel we are nationally divergent and often discordant with respect to philosophies and ethics. Our rules are not the same, in Asia and America. Our languages are no more unlike than our systems of logic or our definitions. Our ethics and our judgments also change in time. It is sometimes said that ethics and manners are matters of geography. In this fluctuant world the geography changes rapidly also, because as man changes his techniques, his tastes and his systems, so also does he change the *significance* of much of his environment.

The main job of some schools of agriculture is to raise food-production per acre. This is condemned by those who say that we grow too much food already. It is praised by those who, as in over-populated Puerto Rico, are trying to get the value of food crops per acre raised to the level of the sugar crop, now 800 per cent. above food crops in value! The Netherlands East Indies tries to meet the reduced demand of world markets for her staple crops (rubber, sugar, coffee) by new crops—tung oil from plants imported from China, tanning material from an Acacia imported from South Africa, wood-pulp from imported pine trees. The ultimate values and distributions of men and resources are unknown to us: we suspect there are no ultimates. We keep learning in the hope of achieving net improvement for the time being. We have also learned that to learn is generally to change.

Most public discussion is babble about agriculture, industry, health, education, security, employment, taxes, war. The voter is asked to express opinions on a jumble of political and social programs by casting *one* ballot. One item in the bundle may be desirable, another highly undesirable. What effect will an act in one field have upon desired ends in another field? The whole must be dealt with, and the individual knows only a small part.

Specialization Increases Satisfaction

Science and much dependent invention has added to our material equipment to so great a degree that it has given "standard of living" the magnitude of a major social force. The individual desires to possess maximum satisfaction, and nature is explored, invention hastened, productive techniques refined to that end. Public health is improved and education made general, in order that life may be more *satisfying*. Fabrics of high utility and pleasing color and design are now available at more generally attainable prices than formerly. The illustrative arts have opened new worlds of enjoyment to millions. Photography alone has vastly increased the satisfactions of mankind. The gains in food production are revolutionary. Quick-ripening wheat and rust-resistant wheat represent two epic breeding struggles with billions of dollars worth of human welfare at stake in the empire of the Canadian Northwest alone.

Let no one dismiss the gains of science lightly with the word "material," as if that didn't matter! We can not overlook the unrelenting fact that all but a few of the people in the world *must* think about food and clothing and power, muscular and otherwise, in order first of all to live. Only a protected life provides the time and strength for continuous thought about meanings, discovery, philosophy, esthetics. The genius alone may be an exception—the miller's son who became Rembrandt, the ploughman Burns.

The scientist no less than the humanist sees the smallness of the spiritual gains in deplorable contrast to the material benefits. What we are trying to do, said one who helped develop Crater Lake National Park, about the forested rim of a high circular bowl in which lies one of the loveliest of the blue waters of the world, is to offset speed. When it took a day to reach the place, people enjoyed it, after earning their enjoyment. Now they rush up to the top in an hour in swift motor-cars, dash to the rim, gasp, "My God, how blue it is!" and rush right down again!

THE EDGE OF THE POSSIBILITIES

Science has become one of the greatest of the adventures of our time partly because it deals with the edge of the possibilities. Man was always working to push past limits, but much new knowledge, and vast organizations in our day have speeded up the process. Man has also discovered that he is changing his own possibilities as well as those of his world as he goes along. He is at the center of his own creative experiment. He has found that what science supplies is not at all an addition, positive and beneficial, until men have proved it so. The whole of that proof is in man himself and not in admiring regard for new facts and inventions. Things and forces, social and natural, good and bad, are added to himself, with the result that ever new possibilities are emerging.

Land pioneering to-day illustrates two such interacting forces—the edge of the possibilities (marginal land) and the desire for an acceptable standard of living. The limits of land cultivation are being traced farther and farther afield. But what is left of pioneer land in the twentieth century is marginal land whose conquest requires both knowledge and better material equipment. The pioneer, seeing himself as part of a wider community, asks for a share in the total benefits. If he is to be empire builder he wants his reward here and now. So, let government do it. Roads, schools, telegraph lines, favorable freight rates, market facilities, low taxes and security from undue risks to health on the frontier are demanded! The protection of children brings restrictions, limitations, conservatism. Things must get better in time or too many families will become habited to the backward look to optimal regions.

Science here serves as a supplement to marginal nature—what crops are adapted to uncertain rains, or late-spring and early-autumn frosts, long haulage and distant demand. If the frontier environment can not be supplemented, social deterioration will take place. It is not enough to push people out upon the land if the land is marginal, risky, remote. Civilization must accompany the settler. Finally, the intending settler must have the will to succeed and he must have the capacity to adapt his musculature to new physical tasks, his mind to the possibilities of new cultural (social) experiments on the frontier, his enterprise to the potentials of the land and the region. If spirit is wanting, if security and accustomed ways are indispensable, if adventure is dead within him, the frontier is no place for him, with or without science.

NEW FRONTIERS IN OLD COMMUNITIES

In the United States applied science has increased agricultural production per worker, through machinery and fertilizers chiefly, and speeded transport, with the result that agriculture has become dominantly commercial and competitive, with marked changes in crop production and type of farming in many regions. Civilization has become increasingly urban, with resulting weakening of both family ties and the neighborhood bond. Machinery has helped create more commerce, more striking and more numerous economic successes and a much higher standard of living for certain classes. Billboards on the highways tell youth that it is "entitled" to a good car, good clothes, a good time. Whether or not that entitlement was earned, what responsibilities go with it, what the advertised product will do to strengthen character or enfeeble it—these things are not put upon the billboards.

We have learned how to feed and breed animals to a high level of efficiency. We expect six thousand pounds of milk a year from a single cow to-day, whereas a hundred years ago two thousand pounds was the average. We know how to preserve food for long transportation. We successfully combat many plant enemies. We have done work upon the grasslands to preserve and improve them, upon soils to determine their rate of wastage and the extent of their need for conservation, upon fisheries as a food source for man. We have calculated the amount of ocean that will be required to sustain a man: a volume of sea water approximately equal to that of a football field covered five feet deep with water and requiring two and a half hours to filter out the zooplankton. If the result seems economically not feasible, science may yet find a way to strain sea water in the likeliest places and provide additional food. Here taste and preference may step in. Will a breakfast of copepods become popular even though we know that they are equal to the best meat in nutritive value?

The triumphs of a scientific age have coexisting population problems of a disturbing character. In the large cities of America there are now about 7 children to 10 adults. If our present reproduction rate remains stationary these 7 children would raise 5 children and the 5 in turn would raise about 3½. The middle class in the cities consistently diminishes its stock. By contrast, the farm population raises about 14 children to 10 adults; the 14 would have at the present reproduction rate about 20 children and the 20 about 28. In 1937 and 1938 the "farm-baby crop" increased, the total for 1938 being the largest since 1926. How long and with what stock will the farm help populate the city? Not enough children are being born to maintain the existing level of the population of the United States. Already the enrolment in the first grade of the public schools has fallen about 100,000 a year since 1930. In the six elementary grades it is declining about 200,000 a year.

It is not easy to point out offsetting conditions to

farm population decline. The electrification of farm operations, the development of credit unions and producers and consumers cooperatives may restore a sense of mastery to and lay a basis for cultural participation by those who are drawn into the struggle that tends to pull good stock to the cities, there to confuse and devitalize it culturally, morally, economically. Between 1790 and 1930 our rural population increased twenty times, while our city population increased three hundred times!

The play of the forces involved in these far-reaching movements and cultural changes, whether self-initiated and free or guided by government, denote a pioneer fringe of high interest in the social field. The situation needs vital leadership, courage and local pride as well as equipment and the experimental point of view. These are old-fashioned virtues and they imply the hard way. Can our entire population rise to such Spartan levels, to self-denying activity, to ideals of independence and strength that evoke dynamic enthusiasm?

Individual and Group

It is a fallacy to suppose that *group energy* is the sum of the individual energies in the group. A man does not make war: a nation or a tribe makes war. A citizen with a gun and no license and a soldier with a gun have two quite different social prospects. A group approves group action which it may condemn in the individual. Our social ethics are not consistent with our personal standards. We are caught up by our generation in the world at large—its ideas, its wars, its conflicting loyalties.

Our culture has developed dysgenic rather than eugenic qualities. Success and its social rewards, implying unusual intellectual and other social capacities, have become linked with diminished fertility. The well-endowed are not reproducing on an adequate scale. This means a steady diminution in the supply of the inherited qualities that brought success. In so far as success is spurious or anti-social the loss of these inherited qualities need not be regretted. In so far as it represents socially valuable qualities it means continued erosion of human character and loss to the race and to civilization.

We are wanting in general acceptance of categories of socially useful qualities. "Eureka, I have found it" means nothing socially until all have found it. "The genius raids . . . the common people occupy and possess." Whatever we gather of scientific knowledge concerning society and how it might be improved is one thing; to persuade or to exercise control in order to bring about desired ends is quite another.

We say that youth should be taught to acquire power to adjust itself to associative living. To a large extent this means the acceptance of the standards of contemporary society, the routine encouragement in oneself of that which society encourages. To carry this out to the fullest extent might be to destroy individual gifts and powers. Social living is not all! Will society foster or permit the not-understood individual variations that include the genius?

The supposition that scientific discovery can be made to bear immediately upon social change, the scientist remaking society, seems faulty doctrine. "Society" is built upon beliefs, traditions, prejudices, suppositions and philosophies, as well as facts, institutions, inventions and materiel—all supported by power or force exercised through *time*. Every advance in applied science calls for a tighter and more inclusive social organization, and it is the state which inevitably controls that organization. In exercising its controls, the state (consisting of determined *groups of men* who hold power, no less than accepted but precarious forms of controls, institutions, and the like) may introduce only those discoveries that suit its book. The holders of power, to whom power is the first law, will scarcely legislate themselves out of office. Moscow, Berlin, London and Washington are alike in this respect.

What is unlike in these four countries is a far more profound thing—the relative degree of freedom for the individual in finding and proclaiming scientific discoveries and in *advocating* their social applications or acceptance. The fight for adoption or rejection of ideas is in the open social arena in democratic countries. If there are dangers we are free to denounce them: no philosophic theory of society stands in the way. By contrast, if it suits the dictator to rest his social argument upon the powerful effects of an improvised environment he rejects the findings of geneticist and eugenist and even a Vavilov loses his job. To be secure as a scientist in a totalitarian country one must first ask a political bureau what is sound.

Let no one suppose, however, that democracy ensures continued freedom. Only when democratic social control of economic life is fully extended shall one be able finally to test the hypothesis that freedom of learning can live in the house of democracy. If the gap between "knowledge" and folk thinking gets too wide we shall all have to turn to the forging of a common method of thought, with no small risk to be run that a sterile generalizer with power may impose a philosophy. This makes the conservation and freedom of the minority a vital need: how often has a single vigorous challenge saved a human situation!

Planning Involves Risk

The tentative nature of social conclusions is often a deciding factor in the rejection of scientific findings. Rightness is not proved except through social experiment that is jeopardized by too short a period of trial, by misrepresentation and misunderstanding of effects,

by the fact that the objects of experiment, men and women, care for different kinds of outcome and such caring may change the outcome. Speed in social reform itself creates a kind of road hazard because of unpredictable turns and their effects, unforeseen impacts and disturbances.

The long view and the short view are difficult to distinguish—a further complication. To preserve our civilization we strengthen our nation, pointing to the competitive situation in the world at large. Through national planning we seek to raise the level of health and strength, to solidify national interest. This will inevitably have the effect of intensifying international competition. Commerce is increasingly competitive and necessarily implies inequality of opportunity in specific lines. In a wide sense commerce is the mother of all wars.

In the international field the triumphs of increased home production, ersatz and autarchy, hailed one by one as proof of growing independence and enhanced welfare—all are advantages that are bought at the price of dislocations elsewhere. Many a national triumph implies a setback for some other nation.

Identification of Causes Precedes Control

Social pioneering has to do with culture in the making, with environment that becomes understood by thinking about the conditions of trial and the effects of error. It deals with inevitably new social forms or old forms adapted to new situations, and becomes ever more complex and overpowering for the individual. Faced by an emergency we develop emergency measures only to find ourselves shackled indefinitely by the emergency forms which we set up, "thereby covering up the conditions that necessitate them."

The first duty of an intelligent society in the modern scientific period is to get at the causes of things. The increase in the general consciousness that wonders exist, that science can create marvels, and that science supplies valuable elements in social living is a gain of the first importance. It has taught whole peoples to look for causes or to expect that causes will be found. Man's greatest hope lies that way to-day. Once causes are located there is no guarantee that a situation produced by a given cause may come to human control. But there is at least *a chance!* Any gains made in this field have appealing potentialities: a basic discovery generally leads to a host of derivative discoveries.

The scientific method is needed nowhere so much as in the sorting of causes and the delimitation of the action of forces supposed to be at the root of our troubles. The United States Bureau of Investigation reminds the Boy Scouts that though they number 1,281,000 they are outnumbered four to one by the 4,750,000 murderers, thieves, burglars, embezzlers, arsonists, kidnappers, extortionists and other criminals. Equally the criminal hosts outnumber the college population of 1,200,000. The director of the bureau does not find the cause of this appalling condition in science: he points to the skulking despoilers and modern-day pirates, "the venal and corrupt politicians" who place personal profit above the rights of decent citizens. But what does he find in the decent citizens themselves? Apathy, lack of interest in honest law enforcement, laziness in the exercise of the power of the ballot. The underworld counts upon these qualities!

A recent advocate of "glandocracy" contends that a society is as good or as bad as its nervous system and its glands, which together make an integrating mechanism whose character profoundly conditions the individual and his attitude towards the society of which he is a part. Given a harmoniously integrated development and the instinctive reactions to good social conditions are more likely to be adaptive and harmonious. Too simplified and mechanical an explanation, one may say. But in any event science deepens the understanding of basic conditions, and searches endlessly for causes in the hope that once they are found a clue to control may follow.

Breaking the Frame

In man's endless adventure in progress, are the objectives to be great works of art, literature and science, or the development of personal health, strength and hardihood joined to national conquest, thereby exalting the nation at the expense of the individual? Or is it sufficient to promote the glory of God by confession, by religious adoration?

Modern science is not without its infective transcendentalism. "Our destiny is in our hands . . . develop all [our] potential activities . . . reject all systems," says Carrel, who believes we can achieve almost illimitable social advance if we but give scope to feeling and genetic possibilities. He advocates resistance to "the tyranny of the quantitative." He would break the frame of the school, the factory and the office, and reject the very principle of technological civilization: mechanical inventions but hinder human development. This seems to overlook certain prime and as yet ineradicable troubles of mankind, such as divergent and conflicting aims, faults of organization, lack of wide social participation in the findings of science.

How resolve the conflicts between classes, reduce the arrogance of nationalism and diminish the chances of war? Which class is to benefit most from a given program, which nation? Are these questions any nearer settlement because of our present wealth of scientific knowledge? Would more scientific knowledge decide the correct and just apportionment of advantages and

privileges and accessions to the forces that raise the standard of living? Without modern scientific knowledge would acceptable solutions be any nearer?

Justice to conflicting groups requires either agreement between them or a universal judge. Our sympathies are weak when we try to put ourselves in the places of men who are far away. We rationalize our own acts to make them good to us and those of the enemy to make them bad. When we fight for the good against the bad it is war nevertheless. Science should provide an even-tempered attitude, but it seems almost superhumanly difficult to cultivate it in society.

We believe in scientific progress, but we reject the findings of science if they disturb an existing going concern, a satisfied community, an assured communication method. We can see only a little way ahead. This produces caution in some. Others exclaim, "if there are remote consequences let our progeny struggle with them." To feed unemployed people we incur a debt. We assume that the fed are worth feeding, knowing that a good deal of unemployment is non-discriminatory. We say that a minimum degree of support is required for an unemployed person, but is not "minimum" determined by worth? If we needed more people would not "worth" rise? Will our children be willing to use the lesser wealth of their time to pay for the judgments of our time? Or do we act like the worker wasp that, when the food supply runs low, bites off the tail of the grub to feed to its head?

In the midst of our troubles, the endless search for simplicities goes on! The despairing layman's answer to the complexities of phenomenonology and doctrine is to set up or accept a new doctrine that is simple and clear and based on authority. There is a clamor for simplicity in economics, politics and education. One hundred books will educate you, and all educated men will then talk alike; a formula can surely be found to break down the barriers to unemployment; if all nations would embrace the principle of world cooperation we should have peace. Editorials, columnists' comment, articles, adjuration, philosophies, tend toward simplicities: ha! here at last is the prophet who has found a way!

There seems to be no straight path to a social goal; evolution seems chancey; progress is only a fitful by-product, says the despairing observer. Our loyalties waver, our beliefs change, our confidence in accepted democratic methods is impaired as we observe the wide variation of intelligence, the difficult task of sustaining interest in community affairs, the low level of individual satisfaction, the little knowledge we have of our leaders, the prime difficulty of bringing democratic method down from a glowing historical abstraction to a concrete activity, the inevitable performance of many functions of government by individuals employing their own judgment, the large element of guesswork in all forms of experiment, including social pioneering, the difficulty in distinguishing between true and false results in short or long periods of time, the haphazardness, the waywardness, the *lack* in democratic judgments, perceptions and actions. To offset these tendencies we offer education, more science rather than less, and "a documented call for action" based upon agreement as to facts by social scientists. Little enough, one must admit.

Analysis and Advance

Social forms can not keep pace with creative thought. A time lag is inevitable because we have found no way to teach and test ideas except through time-consuming and often inconclusive experience. No one subject of study is capable of solving the total array of problems of a people. Science is no more deficient in this respect than social studies themselves. Hear an economist: "Economics is not the science of welfare . . . it is concerned with the relationships of scarce means to given ends." Economists may formulate economic policies through the application of reason and systematic thought to a limited field of human relations; but economics can not provide a total social program, continues Mackintosh. Even the data and hypotheses of economics are limited to a particular age. The subject tends to become less general in its application, a doctrine rather than a science.

In the last quarter of the nineteenth century, modern economic analysis (Marshall, Jevons, Menger and Walras) found a tool of investigation whose focus is the principle of equilibrium and its use has been continuously extended "to attack equally problems of disequilibrium." When the economist is finished with his statistical analysis, he adds imagination, experience and reason to create and test his hypotheses. Are there institutions to carry out an indicated policy? Will the democratic group for which it is designed understand it, accept it and expand it to fit changing conditions? The ends that society has in view are constantly changing and only rarely are they precisely defined. The problems themselves are complex and so, too, are the methods by which they will be solved, whereas public attention is short-lived and public analytical power is extremely limited.

Directives and Limits

From the evidence of paleontology chiefly it was discovered that life from the first had both plasticity and the potentiality of change. Whatever the underlying causes and mechanisms, increasing complexity of form and function has been life's mode. Both muscular and psychological complexity has given organisms increased power (efficiency) in the *use* of the physical environment. Will the process stop with defeat at the physical and psychological assembly known as man, or

will the conscious human turn his unique power of understanding upon himself, both as an individual and as part of a social mechanism?

Faith and method joined to imagination and curiosity still lead us on. Science is the greatest inciter of hope that we know—rational hope that the triumphant methods that have given us deeper understanding and increased efficiency as biological and social mechanisms will one day give us a still deeper insight into who and what we are and what we may become when rational control is extended. As in art and religion so in science—new meanings evolve as the mind continues its unshackling process. The eternal is not brought down from aloft only: it is also sought out and raised up among men. Science is one way of acquiring a knowledge of meanings or of adapting or inventing meanings that give deep human satisfaction —for a time.

OBITUARY

ARTHUR EDWIN KENNELLY

WITH the death on June 18 of Dr. Arthur E. Kennelly, professor emeritus of electrical engineering at Harvard University and the Massachusetts Institute of Technology, electrical engineering lost one of the pioneers who began his professional work when the only practical application of electricity was its use in simple telegraph circuits, but who lived to see the art reach its present highly developed form. His unusual ability, his industry, his gifted personality and his many important contributions to the development of electrical engineering gave him international recognition as a scientist and a teacher. His career was contemporaneous with those other great contributors to electrical engineering such as Heaviside, Edison, Steinmetz, Elihu Thomson, Sprague, Houston, Brush, with all of whom he was more or less closely associated in his professional work.

Dr. Kennelly was born at Colaba, near Bombay, India, on December 17, 1861, his parents being David Joseph Kennelly and Katherine Heycock Kennelly. He was educated in private schools in Great Britain, France and Belgium, and especially at the University College School, London. He was definitely attracted to a telegraph engineering career by attending a public lecture in 1874 at Albert Hall, London, by Mr. Latimer Clark on "Submarine Telegraphy." In 1875, at the age of 14, he was appointed assistant secretary to the Society of Telegraph Engineers (later the I. E. E.), London. In 1876 he entered the submarine cable service of the Eastern Telegraph Company and for several years was engaged in the laying and repairing of submarine cables between England and India, rising to the position of senior electrical engineer in 1886. In 1887 he became associated with Thomas A. Edison in his electrical laboratory at Orange, N. J., remaining his principal electrical assistant until 1894. In 1893 he was made consulting electrician to the Edison General Electric Company and the General Electric Company of New York. From 1894 to 1901 he was a member of the firm of "Houston and Kennelly," consulting engineers. In 1902 he was engineer in charge of laying a submarine telegraph cable for the Mexican Government from Vera Cruz to Campeche. The same year he was appointed professor of electrical engineering at Harvard University, which position he held until 1930, when he retired as professor emeritus. He was also professor of communication engineering and director of electrical engineering research at the Massachusetts Institute of Technology from 1913 to 1923, becoming professor emeritus in 1930.

In 1903 he married Julia Grice, of Philadelphia, who died early in 1935. A son, Reginald Grice, a chemist, of Springfield, Massachusetts, survives.

During 1918 Dr. Kennelly was a civilian liaison officer for the Signal Corps for the U. S. Army in France. He was chosen as the first exchange professor in engineering and applied science at French universities from seven cooperating American universities. Also, he was the first Iwadare lecturer to Japanese universities (1931).

Dr. Kennelly has been honored by many professional and scientific societies and has been the recipient of several medals and similar honors. Space permits the mentioning of only a few.

He served two terms (1898 to 1900) as president of the American Institute of Electrical Engineers, in 1911 was president of the Illuminating Engineering Society, and in 1916 was president of the Institute of Radio Engineers. He held either active or honorary membership in the American Institute of Electrical Engineers, the British Institute of Electrical Engineers, Société Française des Electriciens, Royal Astronomical Society, American Association for the Advancement of Science, the German Elektrotechnische Verein, the National Academy of Science, the Japanese Institute of Electrical Engineers, the American Academy of Arts and Sciences, of which he was vice-president, and many others. In 1935 he was honorary president of Union Radio Scientifique Internationale and in 1938–1940 he was vice-president of the Edison Pioneers.

Among the several awards accorded him were the Edward Longstreth Medal and the Howard Potts Medal of the Franklin Institute, for electrical research; the medal from the Société Industrielle de l'Est; the