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THE ROLE OF PURE SCIENCE[1]

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ONE anecdote has it that, when Gladstone, shown the electromagnetic motor, asked, "What good is it?" Faraday replied, "What good is a baby?" The same question might be asked about science itself, the last great offspring of civilization, sired by intelligence. If no longer a baby, it is at least an obstreperous child, already playing mischievous pranks on its staid mother, and fearsomely regarded by many as irrevocably headed towards a wayward youth and a criminal maturity. Some babies are best unborn; is this such a one? Science, we hear, has warmed our homes but not our hearts, increased our longevity but not our charity, raised our speed but not our hopes, brightened our nights but not our spirit; in short, that it has comforted our flesh but destroyed our soul. Society is sick and science must be poisoning it, for it has been taking great mouthfuls of the bitter stuff; and is it not always something just eaten that is responsible for any ache?

As a physician, I know that a generous portion of peppermint, applied outside or in, neither brings on nor wards off a renal colic; and as a scientist I demand better evidence than "post hoc ergo propter hoc," before agreeing that the social organism is suffering from scientific dyspepsia. But let us clearly understand one another before proceeding.

"Science," as Conklin, retiring president of the American Association for the Advancement of Science, said last week, "is organized knowledge, and knowledge itself is neither good nor bad but only true or false." Pure science is concerned only with understanding, not with using; it might be denounced as valueless, never as harmful. But, comes the cry, this is sophistry; for are not scientists incessantly prating their wares and

[1] An address presented before the American Institute at a symposium on "Some Social Implications of Inventions."

asking society to buy of them; do they not ask to have their researches subsidized and promise a manifold return on the investment; is there any demarcation between pure science and applied technology, which most assuredly does use knowledge for weal or woe. Let me answer in reverse sequence.

Pure science is not distinguished from applied by method, which is identical for both; often not by content, which may overlap in each; but by intent alone. The technologist endeavors to solve a problem with a view to immediate utilization—whether for individual or general ends; the scientist, only to know the solution. His immediate gain is the selfish satisfaction of the climber struggling to the summit, of the poet rounding his rhyme or, if you will, of the successful cross-word puzzler. Hill, a Nobel laureate, has put it well.

> In scientific research we work and work, sometimes for months and years, in digging a tunnel with no apparent results; then suddenly comes the supreme joy of life—daylight begins to glimmer at the end, and in a few minutes we see that nature, after all, has not played us false. To one who works honestly and accurately, these moments are sure to come.
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> It is no use, therefore, to tell a scientist that romance is dead, or a physiologist that physiologic problems are insoluble; the emotions he has experienced in finding new worlds will effectively prevent him from believing you. No joy can be greater than to find convincing evidence for one's faith that nature is ultimately reasonable, no emotion more satisfying than to achieve exact and quantitative verification after months of trial and experiment. Do not think, therefore, that the new laboratories here are peopled with patient drudges, moved perhaps by intelligence but never by emotion. There may be as much real poetry, as much real magic, as much real romance, within these walls as a human life can hold.

Or, again, there is the story of the three hod carriers. On being asked, "What are you doing?" the first replied, "Carrying bricks"; the second, "Earning a dollar an hour"; the third, "Building a cathedral." The last represents pure science.

True, few scientists would justify their labors on such a basis, even to themselves, let alone to society. That may be the reason they wish to do research, not the one that makes them think they should do it, and be aided in the doing. There is, besides, the conviction that the fruits of discovery will benefit all mankind—not at once but soon or late, and riper and more luscious for the waiting. They point out to themselves and the world, correctly, case upon case of the "purest" scientific advances that have risen rocket-like into the intellectual sky only to burst and scatter mankind with riches; induced electricity and the motor, electrons and radio or what you will, hormones and the relief of disease, structural formulae and modern creative chemistry. But, then, pure science is simply long-range application; and motors and radios do make noise, and chemistry creates explosives and tough steel from which to shoot them, and science is daubed with the same paint as technology.

From my view-point, science has another far more valuable contribution to make to mankind than that of upholstering his physical comfort; a vital contribution to his mental climate. And this is at least tacitly recognized by modern educators who include ever more scientific subjects in the curricula. Surely none is so fatuous as to believe that a few semesters of dabbling in physics, chemistry and biology at the high school or college level will prepare the student to build or even repair their autos and radios, let alone to improve upon them. It takes no great erudition to be a handy man about the house, and radio repair men do quite well without having heard of the Schott effect or the uncertainty principle. In biology, where the gulf between common experience and the more esoteric expert knowledge has not yet opened so widely, some practical returns may result from even a casual acquaintance with the latter. It may be useful to know, for example, that spinach is not especially rich in iron, that cathartics do more harm than good, that yeast has no magic dietary virtues, and that patent medicines are, almost without exception, expensive packages of common chemicals and more often harmful than efficacious. But we don't ask the precious hours of youth just to warn them to polish the arsenic spray from their apples before eating them.

Education has two major aspects: utilitarian, vocational training to enable one to live effectively in society, to do; and esthetic, avocational training to enable one to live with himself, to be. The former includes the pre-school shaping into the major molds of civilized behavior, with the aid of the few "do's" and the many "don'ts"; the use of language and number taught in elementary school; and such technical information and skill as are acquired in appropriate trade or professional schools. It is reasonably tangible, and on the whole this education achieves its goal. The esthetic education—the word is not satisfactory for it should embrace more; yet I would prefer it to ethical and so emphasize beauty over good; better is the Greek, Kalos, which includes the good, the true and the beautiful—the esthetic education is the general education which President Hutchins, of the University of Chicago, has recently expounded. It is the appropriate nucleus of high school and college, although not university, training; the very portion of the curriculum which is being enriched with science courses.

This phase of education is confused because its ends are so intangible and the progress towards them so difficult to evaluate. But it is incomparably more important than vocational training, for it shapes the man

and so eventually the society. I hasten to add that esthetic education is not purveyed only in college classrooms at so much a course—it is acquired by steady accretion from family and other social groups. But any formal inculcation of its elements is concentrated at this level, and only by this means can conscious and deliberate direction be given. What, then, should this training for self include?

I submit that it must deal with values and with judgment, must help to establish individual standards and to display materials of worth. Let me be more specific. An ear tuned solely to such strident rhythms as "Yankee Doodle" will not at once respond to Beethoven's softer cadences, melodic though they be; nor will the magnificent panorama of celestial and animate evolution have any appeal to the intelligence that has never soared from a bookkeeper's desk. Certain intellectual and emotional events have value to persons able to appreciate them, and bring additional pleasure and richness into their lives. Man is the highest animal only in the sense that he has the possibility of a greater variety of experience than have others, and the "higher" type of man can savor adventures of the spirit to which the lesser one is insensate. In this sense, then, one may speak of establishing standards of and a taste for the worthy and good—a task of esthetic education.

Besides implanting an urge for the good, the true and the beautiful, this phase of education should offer examples of them and, even more, acquaint the student with their sources in library, laboratory and museum, and encourage him to explore them. Facts and ideas, no less than poems and pictures, may have their beauty. I shall never forget the state of exaltation in which I left the chemistry lecture room after hearing, in the even slightly monotonous voice of Julius Stieglitz, the story of the brilliant logic and inspired experimentation with which Emil Fischer built and identified the unknown but theoretically anticipated kinds of sugar molecules. To one without the requisite background, the lecture would be a tedious mistake. The painter finds much in a picture overlooked by others, the chess-player alone can rhapsodize over a scholarly mate, the scientist can see in the starry sky or the human body beauties invisible even to the lover's eyes. Science, like art, contains the beautiful and offers ever more riches to him who penetrates its terrain from the frontier of dilettante interest to the hinterland of research advance.

The avocational part of education must include, besides the esthetic, still other elements which are of no less importance to the individual and of the gravest import to society. These have to do with truth and judgment, are primarily at the intellectual level, and are quite particularly related to science. To the extent that man acts rationally, he makes progress in the battle with chaos, and he and his society become more integrated and more complex. Irrational behavior, directed by emotion when intelligence is uninformed or in abeyance, is sooner or later retrogressive. This dichotomy of intelligence and emotion, as we shall see later, is rooted in very well-known brain mechanisms.

What are some earmarks of intelligent behavior? First, the absence of superstition, the emancipation from fear of nature and the here-and-now prejudices of the group. I doubt if we of this century and culture can remotely glimpse the load of fear and darkness that oppressed less enlightened souls. Think of the aboriginal gods—lurking in animals and trees, in earth, winds and waters; cruel, demanding, all-powerful; quick to destroy, difficult to propitiate; rendering the future insecure and the present restricted—that peopled the primitive imagination. Recall the native, taught by missionaries to plow deep, who, alone in his tribe, grew grain despite a drought and whose torn-off limbs were scattered on the field to repel the Evil One. Think of our own recent history—the heretics tortured, the were-wolves burned and witches drowned, the sick exorcised; largely in good faith. The Koran was only recently printed in Islam, for it was blasphemy to touch the word "Allah" with pig bristles. Think even of the shrouded nether-limbs of a past generation and the stilted forms of ordinary communication. Our present intellectual climate leaves much to be desired. Heaven knows we do not yet walk in the light of clear day, yet we can look back at the pea-soup fogs of the past with some sense of progress. This I credit to science.

Second, intelligent behavior is marked by tolerance. The new is neither fatuously accepted nor blindly damned. Decisions are reached after due instruction in and evaluation of the facts, pro and con; and action, while not always correct, is rational in the light of the evidence and, since action generates new evidence, it is automatically self-corrective. Need I belabor the past on this point, too, and recall to you the ignoring or persecution of nearly all great innovators of history? Possibly a single instance will be interesting. I quote from the "Report on Technological Trends and National Policy": "In Germany, it was proven by experts that if trains went at the frightful speed of 15 miles an hour on the proposed Rothschild railroads, blood would spurt from the travelers' noses, mouths, and ears, and also that the passengers would suffocate going through tunnels." This, of course, is a mild example and seemingly based on facts and reason, yet a real effort to evaluate, as quantitatively as possible, is conspicuously lacking. As Boake Carter has said, Everyman is the worst censor. Let a radio speaker discuss a live issue, and proponents of one or

both sides flood the sponsor with threats. I contrast the attitude of William Jennings Bryan, who said to an eminent botanist, "I know nothing of evolution but hate it with my whole heart," with that of Thomas Huxley, shown in his famous invocation, "God, give me the courage to face a fact though it slay me." Intellectual honesty is the motif of science.

Third, intelligent behavior does not confuse the symbol with the thing. This requires some explanation. Man tries to understand nature, for his pleasure and profit. But nature is a blooming buzzing confusion of semi-discrete units and systems in a great continuity. Analysis can not proceed until this is ordered into classes—for logic and science deal with the constancies of the category and not with the uniquenesses of the individual. This organization and attendant distortion of "reality" (and let us not enter the metaphysical problem as to whether a real universe exists) is carried out in part by the physiological processes of sensing, in part by the psychological ones of reasoning. Only after grouping individuals into classes can logic proceed, yet any such classification violates the individuality of the members of the class. "Nature," as Whitehead says, "doesn't come as clean as you can think it." Yet, "thought is abstract and," he continues, "the intolerant use of abstractions, is the major vice of the intellect." Words, themselves, are classes and stand only as symbols for something else, symbols which are imperfect and shifting representations of that for which they stand. Their meanings change— as, for example, in the adage, "The exception proves the rule"; "proves" to-day has the meaning "demonstrates," although originally (and with greater wisdom) it stood for "tests" and is still so used in "proving ground." "Facts" also are abstractions and, like words, may lead via the machinery of the most impeccable logic to bizarre conclusions. Even philosophers have fallen into the "error of misplaced concreteness"; most of mankind wallows in it. Label a man or an action bolshevist or fascist and he or it is damned; make the eagle scream out for Americanism and it, with all the lice that inhabit it, is welcomed into our homes. The antidote is science.

I have said that education for truth, for a rational behavior, engenders freedom from superstition and prejudice, inculcates tolerance and the open mind, and brings discrimination of the symbol from the symbolized. I credit science, pure science, with such progress as civilization has made in this direction and maintain that in its charge lies further advance. On what grounds is so much claimed for science? Conklin has summed the case up admirably, ". . . as an educational discipline there are no other studies (than science) that distinguish so sharply truth from error, evidence from opinion, reason for emotion; none that teach a greater reverence for truth nor inspire more laborious and persistent search for it. Great is philosophy, for it is the synthesis of all knowledge, but if it is true philosophy it must be built upon science, which is tested knowledge."

Science is tested and organized knowledge, gleaned and tried with the aid of its powerful method. Surely it is not necessary before this group to reiterate the character of this process—observation, explanation, experimentation and rejection, or, occasionally, confirmation. The elimination of chance by repetition, of extraneous factors by controls and of faulty conclusions by tests of their predictions are commonplaces to you. This habit of mind and action is indigenous in but not confined to the laboratory. It is the flowing river that deposits a rich alluvial delta of new-made wisdom. It is the greatest invention of man, the method of invention.

If our sacred cows of belief and convention can not stand the light of reason they are sickly animals. Do you maintain that science has undermined the foundations of ethics, I reply, "Only of false ethics." There is no conflict between the true and the good any more than between the true and the beautiful. Whichever idols have crumbled with the growth of science were made of clay, and it is well to have cleaned out the debris. Religion is struggling to establish new ethical values; surely science, which has faith in truth and honesty, in patience and order, strains at her side. Perhaps, even, the new ethics will stem from science directly.

On the other counts, tolerance and realism, the case for science, for its method, is unequivocal. Both depend on reason tempered by facts, on logic checked by empiricism at each extrapolation, on drawing honest conclusions. He who would navigate onwards into the unknown must steer on the star of truth with the compass of logic, but he dare not neglect to take frequent bearings with the sextant of observation. And this is the way of science. Pure science has these great contributions to make to society, through general education, a tried methodology and disciplined minds with which to attack its problems.

Many of you, I am certain, are now about at the bursting point of indignation with my elegiac mood. "Man, alive," you would say, "stop talking like an evangelical Pollyanna and look at some facts yourself. Science has been taught in increasing intensity for a century or two and you have already admitted that we still are clouded in prejudice, intolerant to an extreme degree, and regularly misled by words. And you can't wriggle out of it by saying that science has not adequately reached the masses, for we know any number of scientists who are as egregious asses as the rest of

us when they dare to emerge from their narrow specialties, which, by the way, they rarely do."

Yes, I know. Much that passes for science is utterly trivial and many of its supposed devotees are dull followers of a trade. Don't you, my friendly challenger, make another error and mistake the word for the thing. If you define "science" as the produce of departments of physics, geology, botany, etc., and "scientists" as the men who people them, we are not talking quite the same language. One must distinguish religion from creed, religious experience from formal worship, creative painters from rote copyists, brilliant explorers from the gleaners that trail them, intellectual calisthenics from a mental Turkish bath.

Yet I must admit there is something to your position. Scientists to-day fall far short, on the average, of what one might expect from them. It is, perhaps, possible to trace the reasons. A century and more ago, science was an esoteric pursuit. The men who followed its call were amateurs, usually wealthy or patronized. They worked largely as individuals at an avocation or hobby, like philatelists to-day, because they enjoyed it. They were eddies in the social stream, amusing or ludicrous to the serious-minded of the time but not important. One cultivated science as one cultivates a garden, without ulterior motive beyond the satisfaction of watching its lovely flowers unfold. Not so to-day. Science became useful, its flowers yielded expensive perfumes and healing drugs, and it was taken up by the best society. Departments of science crowded into and multiplied within universities, even high schools; research institutes sprang up; industry sprouted laboratories or subsidized technical schools and plants; great foundations pumped nourishment into all these, aided here and there by government. Technology spread everywhere, new industries based upon it grew into gigantic stature. And men were needed.

The little band of scholars quietly exploring intriguing corners of the unknown was lost in the surge of recruits. Science had become a respectable profession and, if not promising quite the financial success of the older ones, it had other desiderata, as security. Students rushed to grasp the new opportunities and were welcomed into the schools and later into the industries. Some became the teachers for later groups. The main orientation was utilitarian, the motives, economic, the caliber, small. Democracy triumphed and the intellectual aristocracy was dead.

But if this were the whole story, my case would be barren, indeed, with real science necessarily the prerogative of the elite alone. A more fundamental problem exists than the mere expansion of science due to social usefulness. This, in itself, is probably to be applauded; certainly there is no more cause for dismay than is offered by the existence of a medical profession. The trouble is with education as a whole. It is too much a Turkish bath.

I have described earlier what education should be and the pivotal position in it of the scientific attitude. But, although courses in chemistry and physiology flourish everywhere, few students are ever given a glimpse of science. They learn the facts, theories and techniques of a subject, yes, even how to plan and evaluate experiments, but they rarely are exposed to the true scientific spirit. How could they be when the men who teach them do not have it? Some years ago I heard a student who was just about to receive his Ph.D.—mind you, his degree as doctor of philosophy—tell in a seminar about the French "anatomist," Descartes. The name was obviously new to him, he pronounced all the consonants and misplaced one—Descrates. He is now teaching science to another generation.

There is a cycle in education which might be benign but is still vicious. Bad teachers teach students badly so that they in turn become bad teachers. Ignorance, like syphilis, would be eliminated if we could only make it spare one generation. What a stride forward humanity would take if just one crop of youngsters was put through the hands of really good teachers! This is just pleasant day-dreaming; we have not enough good teachers nor prompt means of developing them. Yet the situation is not hopeless, and civilization has always had to pull itself up by its bootstraps. Leaders do emerge, talent does exist, and barbaric hordes do become cultured. Real scientists and teachers are among us in considerable number, and when society is prepared to encourage and support them, and recruit to their ranks other men of ability, progress will be rapid; for, as I have shown elsewhere, the scientific spirit *can* be imparted to students.

There is one more point to make about teaching scientists and educators in general, especially in this country. Let me say it quickly and have it over, for it is rather shameful. The truth is that those in social and financial power—donors, governments, founders—have so little confidence in professors that they do not trust them to run themselves, let alone others. Almost without exception, a separate body—of trustees, president, deans and other administrative officers—runs our universities and the faculty pretty much does what it is told. Administration is often enough excellent, and academic freedom is jealously guarded in any university worthy of the name, but the fact remains that our institutions of higher learning are painfully different from a republic of scholars.

Is it any wonder, then, that science has made no greater impress on the mind of man and that scientists are so often found wanting? They have nearly all been taught badly, except in some limited field of proficiency; they have been debased by the rapid and in-

completely assimilated influx of opportunists; they are little prized, except for their technical skill; of course they are oblivious to or prejudiced about most problems of society. A man may do sound scientific research yet not exhibit generally the scientific attitude nor impart it to his students. But one who has not even this apprenticeship to truth is likely to do less well.

Let us return to our sick society, for something surely ails it, although I hope to have shown it is not pure science. What medicine does it need, and who should administer it? The treatment depends on the diagnosis, of which more shortly; the scientist has often been put forward as the physician. Now I suspect that a really first-class scientist may make a first-class statesman—was not the chemist, Eliot, one of Harvard's greatest presidents?—but I doubt if he would be more likely to be so than other first-raters. The scientist has on his shoulders even now, besides his chosen task of research, the duties of teacher and often philosopher (as well as citizen and individual), and that of administrator is not lightly to be assumed. Further the innovator is rarely the developer; not Trotsky but Stalin directs the destiny of Russia. No one man has genius enough to run a nation, and it seems wiser to have in charge a skilled politician who relies on expert scientific advice than to have a skilled engineer advised by expert politicians. The important thing is that the best knowledge, the best brains and the best will be drafted to the task. This is not easy of achievement; but more later.

Now, what ails society and puts the time out of joint? Is it technological advance as such or the discrepancy between this and static institutions or something else entirely? Two accusations are made against technology—it has made war horrible and peace ugly and impoverished. As to the former, gunpowder is only powerful—not good or bad. If used for ill, the fault is with the user. Poor old human nature must take the blame. And although it is true enough that it is better to keep powerful weapons from irresponsible hands, the only realistic solution here is to eliminate the irresponsible for, willy-nilly, technology will march on.

The influence of technology on our work-a-day society requires further comment. Ogburn, in the report of the committee already referred to, points out the sequence of changes following a new and important invention. First there is a lag (a third of a century or better) before it is accepted and applied; then comes its technical use and the attendant economic changes; later, often much later, there follows a modification in social institutions—home, church, government; and only at long last do the customs and beliefs of the populace fall in line. The spinning jenny is blamed for the industrial age. Yet it was merely a more efficient instrument for getting work done, just as the electric vacuum cleaner is more efficient than the broom. Have you ever heard the myriad household aids blamed for social dislocations—the electric washer and iron and mixer and cleaner and stove and razor and light? Oh, yes, we grumble about the lady of the house wasting her time on bridge and her money on beautification now that the galloping watts leave her skin soft and her hands potentially idle, but we love her all the more.

Had the new tools of industry likewise remained in the hands of the single worker in his house or shop man, like woman, would have been the gainer. But, of course, they were too large for the individual home and purse of the worker and note, please, for the purse of the inventor as well. So they passed into the hands of the entrepreneur and banker who, in full harmony with the current mores, exploited them to the limit for their personal gain. There resulted more goods and profit from less work, but the owner took the profit and the worker lost the work. Less skill was required, so women and children were hired instead of men and more cheaply. There followed in course the decay of the family and the rise of the slum. Later, much later, the social ethics stirred in its sleep and folk began to look askance at the robber barons of a new age of feudalism.

So far you must all agree, these evils following invention (the accelerated tempo of life in general is a separate question) did not flow from the technical discovery but from its befuddlement with property rights which took precedence over human rights. To-day the mass of the people repudiate such standards and many nations have expressed a collective discontent by plunging into great social ventures and new -isms. The world is groping in many directions for new air and light; all sorts of expedients are being tried, blunderingly; but the spirit of change is marching and can not be stopped.

I should be a poor scientist indeed, with my lack of knowledge and experience, to presume to know the proper answer. The diagnosis, I think, is fairly clear, but the disease is unfamiliar and the therapy to be worked out. But this much I must say, as a scientist. Here is an empirical problem requiring rational solution more urgently than any in human history—and the scientific method is the one best proven instrument for solving it. Even this may not succeed, but then no other attack will either and humanity will grind itself into decline.

It may be worth a final few minutes to examine more closely the possibilities. One of the most significant of technological advances is that of communication. The talking movie and the radio at present, to be supple-

mented at any moment by television and the home printed news sheet, afford amazing means for influencing the collective mind. Entering the home, reaching the child, they carry terrific power for leading the intelligence on by education or debasing it by propaganda. And remember human beliefs are social facts; for man's acts depend (in part) on what he thinks is true, aside from its objective truth or falsity. It will not do any longer to cleave to a laissez-faire principle, for it is being flagrantly violated. Once a dictator captures the people's mind by censoring the unpleasant and broadcasting the spurious they are indeed his slaves, for even reason is powerless with faulty materials. Something must be done, now, to secure for the ends of proper education these channels of influence.

But who shall control communication and make the all-important decisions as to what constitutes proper education? Is not human nature such that any man or any group wielding this enormous power will drift into selfish tyranny? Perhaps so; but this is certain, that there will be least abuse at the hands of men conditioned to intellectual honesty, tolerant judgment and respect for truth.

At least it would be a simple matter even yet to keep the control of technology, and so of social institutions, in the hands of scientists. Scientific discoveries of the past have, by and large, been given freely to the community; even the detailed applications have not often been patented. They have been exploited by others for private ends, sometimes in anti-social ways. As great industries of the present have arisen from past research, so surely those of the future are being born in the laboratories to-day. If individual scientists or, better, single universities or, better still, national scientific societies or, best of all, a distinguished body representing all science, and government as well—as the National Academy of Sciences or the National Research Council (to consider the national rather than the international level which must eventually supersede it) —were to patent future discoveries and control their development and their impact on society we would have a better world. Not perfect, ever, but improving, probably; and surely with a greater chance of success than when, as now, the implements of propaganda and control are allowed to fall into the most grasping and ruthless hands.

Scientists are more men of thought than action, they prefer to have the evidence, which is never all in. All agree that, to-day, by applying known or strongly surmised genetic laws to man the breed could be altered very considerably. But they are not certain what to breed for, have little control of the breeding, and fear the consequences of mistakes in the form of ill-begotten beings which may not be destroyed. All agree that, to-day, with a growing knowledge of educational aims and techniques, with a sound child psychology, the thoughts and even the more important motives that determine action could be modified. But they are not certain of what to educate for, have little control of mass education, and fear the consequences of mistakes in the form of neurotic misfits which may not be curbed. This attitude is sound—but only if time permits a proper evolution. This is not so; power multiplies and usurpers are reaching for it, dictatorship is in the air, events are rushing a decision. I believe that men of good-will must act; I would rather trust the destiny of civilization to even a second-rate group of scientists and educators than to the present type of dictator. They at least would aim for truth and profit by errors. Perhaps the world will owe Hitler a debt of gratitude, after all, for pointing the issue sharply enough to force better men to act.

A final word. The fate of our institutions and culture depends, when all is said, on the few who wield great power. Whether scientists, bankers or politicians, they remain still men. The great questions are: first, is the human intellect capable of solving, at any time in the future and with any amount of scientific analysis and even experiment, the labyrinthine problems of human relations; and, second, will not might forever make right, so that the selfish, ruthless and aggressive will arrogate control, however the game is played? The answers lie in the future, yet I shall be reckless and assume the role of prophet for the nonce.

Science is not able to deal with all nature. We have already seen that the individual as an individual is outside its province. The "private" lives of each of us may be penetrated by esthetic or religious or scientific experience but are not subject to scientific analysis. But the class, even the individual as an organization of simpler units, lies within its capacities; and social problems are no more insoluble than biological ones. Man's understanding and control of the body to-day are no less than they were of inanimate nature a century back. Living things are vastly more complex than non-living, just as social beings are more so than solitary ones. Each complexity as it is approached seems to resolve itself into many simpler problems and the mind has rolled over them. It is as gratuitous an assumption that man's intellect will be baffled at the level of social analysis as was the one that blood would spurt from his nose if he moved at the frightful speed of fifteen miles an hour. I see in question one no cause for pessimism.

The second is more uncertain in my mind. The human brain contains an old portion, the hypothalamus, essentially like that of all his vertebrate relatives, and a new portion, the cerebral cortex, most richly expanded in him alone. The old brain is concerned

with the emotions, the new one with intelligence. Fear and rage he shares with all, judgment and foresight are almost uniquely his. It would probably be impossible, surely unwise, to eliminate the selfish elements of self-preservation from man's make-up; but it may be possible and is surely desirable to control and guide them. Knowledge is cumulative in time, generation building on generation, while emotion is not. Perhaps cerebral control is increasing. Modern psychiatry is finding the hidden springs of behavior and modifying their flow. Men will probably always want more than their share, but perhaps it will not always be of the same things. The mass desideratum now is money, yet large groups of men have completely renounced this end for another; for example, fame. As man learns more of himself, his neural mechanisms, the hormones that modify them, the drives they generate, and the personal and social consequences of his acts, much control will undoubtedly be possible. And this knowledge will be deposited only by the stream of science. I am perhaps not overly guileless in believing that reason will sufficiently dominate emotion to keep a functioning civilization from perishing. Some emotion is needed, but the future of society is a direct challenge to the cerebrum of man and to its tool for rational advance—pure science.

OBITUARY

ALBERT SHERMAN

DR. ALBERT SHERMAN, research associate and Stephen S. Wilder fellow of the Basic Science Research Laboratory at the University of Cincinnati, died suddenly on July 1, following a period of illness. He was a brilliant theoretical chemist and probably the leading authority on the practical application of activation energy calculations to chemical reaction rates. His death at the age of 31 is a handicap to the development of this new and important branch of chemical kinetics. He has written twenty articles in the field of mathematical chemistry published in several journals, but chiefly in the *Journal of Chemical Physics*.

Born and raised in San Francisco, Dr. Sherman was graduated from the chemistry department of the University of California and went to Princeton University, where he received the Ph.D. degree in 1933. Here he came under the stimulating influence of Professor Eyring and Professor Taylor, and in this period published several articles in the rapidly developing application of quantum mechanical calculations to chemical problems such as adsorption, and deuterium reactions. He received a National Research Council fellowship and went to the University of Wisconsin, where he remained as fellow and research associate with Professor Daniels until 1937, except for a second appointment to a National Research Council fellowship to study in England with Professor Lennard-Jones.

Of this period of his scientific work, three outstanding papers are typical—a long review article with Professor J. H. Van Vleck on the "Quantum Theory of Valence," an article on the "Addition of Halogens to the Double Bond" and an article with Moelwynn-Hughes on the various types of interaction between solvent and solute and their influence on reaction rates.

A year ago Dr. Sherman was appointed to an interesting position on the staff of the Basic Science Research Laboratory at the University of Cincinnati. He had the opportunity of giving advanced courses in quantum mechanics, valence and thermodynamics, directing research and cooperating with the industries around Cincinnati. At the Symposium on Recent Advances in Chemical Physics of the American Association for the Advancement of Science, Dr. Sherman gave a paper on the "Calculation of Activation Energies," and in a forthcoming book he has contributed a chapter on the "Theoretical Basis of Halogenation Reactions."

Not only in his publications has Dr. Sherman helped to advance chemistry but also in the help which he was constantly giving to other investigators. He was liked and respected by all the graduate students with whom he came in contact at Cincinnati, at Wisconsin and at Princeton. His advice was eagerly sought by many in getting the most possible out of a series of experimental measurements, and both in formal lectures and informal conferences he stimulated others to more mathematical and more valuable treatment of chemical problems.

Dr. Sherman is survived by his parents and a sister in San Francisco. He is survived by Dr. Jack Sherman, an identical twin brother, who is also a prominent mathematical chemist, located at the laboratory of the Universal Oil Products Company.

FARRINGTON DANIELS

ELLIS STANLEY JOSEPH

THE death of Ellis S. Joseph from a heart attack on September 16 ended the career of one of the world's foremost animal collectors. Mr. Joseph was 66 years old, and had been in virtual retirement for the past five years due to ill health.

Born in Bombay, India, of English parents, he was educated in an English school in Shanghai. His father, said to have been a wheat farmer and horse owner in India, wanted the son to become a doctor. But the lure of travel and adventure was too strong, and when only eighteen the young Joseph began making expeditions