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THE RESEARCH CHEMIST, MANKIND'S DEVOTED AND INDISPENSABLE SERVANT[1]

By Professor MARSTON TAYLOR BOGERT

COLUMBIA UNIVERSITY

"TAKE interest, I implore you, in those sacred dwellings which one designates by the expressive term Laboratories. Demand that they be multiplied, that they be adorned. These are the temples of the future—temples of wellbeing and of happiness. There it is that humanity grows greater, stronger, better."

So spoke the immortal Pasteur, and I tender my warmest felicitations and congratulations to Trinity College and her friends on the noble way in which they have responded to that call by the erection of this splendid new Chemistry Building.

I am confident that you all feel as I do, that colleges and other educational institutions exist primarily for service—to the community in which they happen to be located, to the state, the nation and the world.

[1] Address delivered on the occasion of the dedication of the new Chemistry Building of Trinity College, Hartford, Connecticut, October 9, 1936.

Not infrequently, the public as well as the students get a somewhat distorted perspective of the relative importance of a college's manifold activities, in living up to this ideal of service and in meeting the obligations and responsibilities it imposes. There can be, it seems to me, but one order in which to arrange the more obvious of these duties. First and foremost comes the making of great citizens and courageous leaders, of sterling character and high ideals, never more needed by our country than now. The institution that fails to keep this primary purpose always before it voluntarily sacrifices its birthright and is unworthy of support.

As Edwin Markham so admirably expresses it:

> We all are blind until we see
> That in the human plan
> Nothing is worth the making if
> It does not make a man.

Why build these cities glorious
If man unbuilded goes?
In vain we build the world, unless
The builder also grows.

Next, I would place the arousing in the student of an enthusiastic interest in his studies, for once that inspiration is awakened he will require no urging to learn their factual foundations. This is where the genius of the teacher is immediately evident. Students are quick to sense, almost instinctively, whether their lecturer loves his subject or not, and only the individual who himself possesses that divine fire of inspiration can hope to pass it on to others. There is no greater boon within the gift of the teacher.

In third place, I would put the inculcation of the bare facts themselves, for the world is not so much concerned about what you know as it is about what use you make of that knowledge.

The multifarious opportunities for service which chemistry offers may be grouped under the following general headings:

I. The *dissemination* of knowledge by writing, lecturing and teaching.

II. The *application* of existing knowledge to the solution of the problems of industry and of public life.

III. The *discovery* of new knowledge.

It is the last of these, namely, the discovery of new knowledge, that I would like to discuss with you for a few minutes this afternoon, taking as my text, "The Research Chemist, Mankind's Devoted and Indispensable Servant," for you are here laying the foundations for the future life work of many hundreds of chemists, and I welcome the opportunity of telling this group of students something of the fascination and allure of the career of the chemical investigator, and of endeavoring to make clear to my audience why he should be regarded as a useful and irreplaceable citizen.

All chemical industries, as well as a host of others, owe their origin and development to the discoveries of the research chemist. You are all perfectly well aware of this, and I shall not tax your patience by going into details, for I wish to present the subject from a somewhat different point of view.

In ancient times man searched the corners of the then known world for precious spices, perfumes and dyes; great caravans made long and perilous journeys, and galleys plied "the seven seas" on similar errands. Only kings and nobles or the richest of the proletariat could then afford such luxuries. But to-day science, the greatest and most altruistic of all democratizers, has brought all these and thousands of other equally precious substances within the reach of even the poorest of our people.

The "Philosopher's Stone," the "Grand Elixir" or the "Magisterium," as it was variously called in the Middle Ages, sought so eagerly by the alchemists of the Zlata ulička or Gold Alley of Prague, and which was not only to transmute baser metals into gold, but also to restore the dying to life, has at last been found in the trained intelligence and fertile imagination of the scientific investigator. Its name is scientific research, and it is daily transmuting baser materials into products of inestimable value to the community, relieving human suffering, conquering disease and saving human life. It is the mainspring of our progress and the measure of our civilization.

The army of scientific investigators are the real "shock troops" of civilization, always on the firing line and ever penetrating deeper and deeper into the hostile territory of those common enemies of mankind—ignorance and darkness, superstition and intolerance, poverty and famine, disease, pestilence and death.

The value of new facts carefully determined and recorded is not always immediately evident. Years may, and often do, roll by before they are utilized. The late Elbert Hubbard used to say that "in these days, the man who says that a thing can not be done is quite likely to be interrupted by some idiot's doing it." As a child, my parents used to read to me a poem entitled, "Darius Green and His Flying Machine," written in ridicule of the possibilities of aviation. As a boy, I pored with great delight over Jules Verne's "Twenty Thousand Leagues under the Sea," which foreshadowed our modern submarines, and was generally regarded as merely another wild flight of the imagination.

"But would you really like to hear some music?"

I assured her once more that I would.

"Come, then, into the music room," she said, and I followed her into an apartment finished, without hangings, in wood, with a floor of polished wood. I was prepared for new devices in musical instruments, but I saw nothing in the room which by any stretch of imagination could be conceived as such. It was evident that my puzzled appearance was affording intense amusement to Edith.

"Please look at to-day's music," she said, handing me a card, "and tell me what you would prefer. It is now five o'clock, you will remember."

The card bore the date "September 12, 2000," and contained the longest programme of music I had ever seen. It was as various as it was long, including a most extraordinary range of vocal and instrumental solos, duets, quartettes, and various orchestral combinations. I remained bewildered by the prodigious list until Edith's pink finger-tip indicated a particular section of it, where several selections were bracketed, with the words "5 P.M." against them; then I observed that this prodigious programme was an all-day one, divided into twenty-four

sections answering to the hours. There were but a few pieces of music in the "5 P.M." section, and I indicated an organ piece as my preference.

"I am so glad you like the organ," said she. "I think there is scarcely any music that suits my mood oftener."

She made me sit down comfortably, and, crossing the room, so far as I could see, merely touched one or two screws, and at once the room was filled with the music of a grand organ anthem; filled, not flooded, for, by some means, the volume of melody had been perfectly graduated to the size of the apartment. I listened, scarcely breathing, to the close. Such music, so perfectly rendered, I had never expected to hear.

"Grand!" I cried, as the last great wave of sound broke and ebbed away into silence. "Bach must be at the keys of that organ; but where is the organ?"

"Wait a moment, please," said Edith; "I want to have you listen to this waltz before you ask any questions. I think it is perfectly charming"; and as she spoke the sound of violins filled the room with the witchery of a summer night. When this had also ceased, she said: "There is nothing in the least mysterious about the music, as you seem to imagine. It is not made by fairies or genii, but by good, honest, and exceedingly clever human hands.". . .

You may be surprised to learn that I have just been reading from Edward Bellamy's "Looking Backward," written just 50 years ago as a vision of what we might expect by the year 2000. Actually this dream became fact in one quarter of that time. Some one has well said: "Do not despise the dreamer. Be one yourself. For every great achievement is somebody's dream come true." And, as Vice-President Kettering, of the General Motors Corporation, so strikingly puts it, "No one can look into the future except through the windows of the research laboratories."

Many other things which seem impossible to-day will be matters of such everyday knowledge a few years hence as not even to evoke passing comment. The pathetic side of this is the realization that, aside from the fact that our national recovery would thereby be more quickly and more fully realized, an incalculable amount of human suffering and thousands of human lives could be saved by speeding up our research program through more liberal financial assistance. It is your life and the lives of those nearest and dearest to you that are at stake. What are you going to do about it?

Perhaps the most discouraging factor in the present situation is the attitude of our own Federal Government. Although expending billions of dollars, not alone for much-needed relief, but also for about everything else under the sun, the appropriations for the support of research in the all-important domain of the natural sciences have been cripplingly reduced, trained investigators have been turned adrift, to swell the already distressingly large army of unemployed, and taxes have been enacted the effect of which will be so to penalize wealthy individuals as to make it increasingly difficult for those who have heretofore been the principal benefactors of our educational and research institutions to contribute to their support. This, too, at a time when these institutions need such help most urgently, because of the greatly diminished income from their investments.

We flatter ourselves as being the world's most progressive nation, but President Compton, of the Massachusetts Institute of Technology, chairman of President Roosevelt's Science Advisory Board, in his masterly address on "The Government's Responsibilities in Science"[2] remarks that, "It is interesting and somewhat disheartening to note that our country, with all its boasted progressiveness, has paid less official attention to science as a means of combatting our present difficulties than any of the other great powers."

The governments of Great Britain, Italy and Japan are all awake to the dependence of their nations upon science and are officially encouraging its development with steadily increasing liberality. Russia has established, under her Academy of Science, over 200 great research institutes, for work in pure science and engineering, with palatial buildings and the finest equipment obtainable. Her appropriation for these institutes and the advancement of science is reported to exceed any other item in her national budget—even that for military and defense purposes. While our own government, with an appropriation of less than one half of one per cent. of its 1936–1937 budget for the same purpose, staggers along like a drunken sailor, throwing money right and left, content in the fatuous delusion that because of our marvelous inheritance we can hold our place in the sun with the expenditure of the barest pittance for science, and scornfully indifferent to the fact that for a nation, as for an industry, scientific research has ceased to be merely the price of progress. It is to-day the price of existence. Which shall it be, scientific leadership or ultimate national decline and fall?

In recent years there has been much thoughtless railing, often by those who should know better, against science as inimical to the well-being of the race, because of the evil uses to which it is sometimes put. Even the newspapers have carried such scare headlines as "Chain the Mad Dog of Science."

As a direct consequence of the use of so-called "poison gases" in the world war, chemistry and the chemical investigator have been defamed and maligned as being directly responsible for the introduction of this new horror into war. As well might one condemn the manufacturer when a woodman's axe was used to

[2] SCIENCE, 81: 2102, 347–355, April 12, 1935.

murder a neighbor. Should disease germs be employed in future wars, a possibility which has been suggested by various writers, medicine and the medical profession, although wholly blameless, are likely to be subjected to similar abuse.

Practically all the toxic chemicals used to any extent during the world war were well known long before that conflict. They had been discovered by research chemists, in their efforts to contribute to the advance of civilization, and these scientists were assuredly in no way responsible for the pernicious uses to which their discoveries were subsequently put. Some of these chemicals have useful peaceful commercial applications. Phosgene, the chief killing gas employed by both sides in the war, is the initial material for the manufacture of some fine dyes, as well as of certain drugs for the alleviation of human suffering and the cure of disease. Chlorine, the first "war gas," and which served for the manufacture of other deadly gases, is the same chlorine as was used to manufacture the chloroform for surgical operations, and for the preparation of potent healing wound disinfectants, as well as to save our soldiers' lives by sterilizing their drinking water.

Lord Asquith, soon after the close of the world war, wrote:

> The first and most obvious experience of this war is the unexplored and still incalculable effect of the harnessing of science to the chariot of destruction. . . . If she is to be diverted for another 20 years into the further elaboration of the mechanism and chemistry of destruction, we may as well pray for the speediest possible return of the glacial epoch.

And the Right Honorable Richard B. Bennett, Prime Minister of the Dominion of Canada, in the course of an address delivered on Armistice Day, 1934, broadcast over an international hook-up, under the general title of "The Family of Nations," had this to say:

> To chemistry we are indebted for modern anesthetics, which before the 19th century were unknown. Their general introduction into surgical practice is one of the most powerful agencies in the alleviation of human suffering. But to our horror we know that the chemist can appear in a role of devastation to herald a program of destruction and annihilation yet only in its infancy. The inescapable conclusion is this: that the laboratories of science can not be left as the playthings of those who vie with each other in the technique of human slaughter, but must be reclaimed for the beneficial use of mankind.

Scientific knowledge is power and, like any other kind of power, political, financial, or what not, may be used either benevolently or malevolently. Of course, intrinsically power is neither good nor bad. It is only the purpose it serves which can be so described, and this carries the responsibility back to where it obviously belongs, namely, to the individual employing it. As well might one condemn religion, because in its name have been committed some of the bloodiest and most revolting crimes in history. A scientific invention or discovery may be used either for or against humanity, and no one can predict just what will be its final balance sheet. It is manifest, however, that there would be neither scientific discovery nor the dissemination of scientific knowledge, if they were to be limited to those facts which could be guaranteed to have only benevolent applications.

Like an individual, a nation that believes its existence to be at stake is quite certain to make use of any weapons or knowledge likely to aid in its struggle for self-preservation. As science is one of the most potent of all weapons, it behooves us to keep this fact constantly before us.

The Bishop of Ripon suggested nine years ago that all physical and chemical laboratories be closed for a period of ten years, in order to give the world a chance to assimilate the mass of new and undigested knowledge already accumulated. The impracticability and futility of this suggestion were clearly and forcefully presented by a number of writers, immediately following the publication of the bishop's address. And yet the bishop was quite correct in asserting that the discovery of new knowledge is advancing more rapidly than our understanding and utilization of it.

"Some of the appalling contrasts between scientific progress and social stagnation," which confront us so threateningly to-day, as the direct outcome of this lag between knowledge and practice, were vividly set forth in the remarks of Dr. Edwin G. Conklin, as president of the American Association for the Advancement of Science, at the semi-centennial celebration of the Society of Sigma Xi.[3] As new facts are recorded, the possibilities of their interdependences and interrelations increase in geometrical ratio. There are splendid opportunities now for service by those who will patiently and painstakingly study, collate and interpret this overwhelming and rapidly increasing mass of information in all its possible applications and implications.

Some 200 years ago, Sir Joshua Reynolds wrote:

> It is indisputably evident that a great part of every man's life must be employed in collecting materials for the exercise of genius. Invention, strictly speaking, is little more than a new combination of those images which have been previously gathered and deposited in the memory: nothing can come of nothing: he who has laid up no materials can produce no combinations. The more extensive, therefore, your acquaintance is with the works of those who have excelled, the more extensive will be

[3] SCIENCE, 83: 2165, 607–609, June 26, 1936.

your powers of invention, and, what may appear still more like a paradox, the more original will be your conceptions.

The greater the power under man's control, the greater his possibilities for good or evil, and the heavier his responsibilities.

The central and eternal problem is man himself, not science, nor an accumulation of undigested knowledge. Man's mastery over the forces of his universe is growing far more rapidly than he himself is developing the qualifications or character to be safely entrusted with such vast power. It is entirely conceivable that the end of life upon this planet of ours may be brought about by man himself, through the loosing by some miscreant of uncontrollable devastating forces. This thought has been expressed before by various speakers and writers, notably by Bertrand Russell in his "Icarus." Think of the havoc which can be wrought already by such forces as fire and pestilence! The only answer is to breed better humans, and in this scientific research can and will unquestionably play a leading rôle.

To quote once more that great benefactor of mankind, Louis Pasteur:

> Two opposing laws seem to-day to be in combat—a law of blood and death which, daily devising new weapons of war, compels the people to be prepared always for the battlefield; and a law of peace, work and welfare, which is concerned only with the delivery of humanity from the scourges which beset it. The one seeks only violent conquests; the other the relief of mankind. The one places a human life above all victories; the other would sacrifice hundreds of thousands of lives to the ambition of one man.

Our loss in the world war was approximately 50,000 dead; but in the same period 180,000 of our people died of cancer and over 400,000 of influenza. The total deaths in the world war in all countries concerned have been estimated at 10 million or more; yet Pasteur's discoveries have probably saved many more human lives than this. If this seems an extravagant statement, I would remind you that in the year 1347 the Black Death was brought to Genoa from the Crimea by an Italian advocate, Gabriel de Mussis, and in 24 months 25 million people died in Europe of this terrible pestilence.

The chemist's inheritance is a fair land of vast extent, boundless resources and unrivaled opportunities for service. As yet, he has penetrated it to only an infinitesimal extent, but sufficiently far to learn that the farther he advances the more marvelous are the wonders it discloses.

The chemical investigator is a real adventurer and explorer, and the dangers which confront him are just as real and just as great as those which beset the path of him who would force his way through the tropical jungle or brave the rigors of the Antarctic. He has this great advantage over those whose field is merely the superficial physical features of the earth that, whereas already there remains but little of the earth's surface unexplored, even at the poles or in darkest Africa, and this little is rapidly diminishing, the chemical explorer has an ever widening field for his adventures, as each succeeding discovery opens new vistas of the limitless unknown beyond.

It is that vast unknown which ever beckons and lures him on, which he follows with all the zest and excitement of the chase. Like the "call of the wild," it is a call which never fails to awaken a vibrant response in the heart of the born scientist until that heart is stilled and life itself, the greatest adventure of all, is over.

After 40 years' experience, I say without hesitation that there is, in my opinion, no career which can for a moment compare with that of the investigator in the realm of the natural sciences, in the fascination and magic of the work itself, the satisfaction and contentment which flows from doing something which really seems worth while, the inspiration and thrill of seeing a little deeper into the unknown, while still before him, in indistinct and hazy outline, he discerns vaguely great fundamental scientific truths and generalizations, which he knows are there and towards which he eagerly fights his way.

The adventurer in a new land can rarely foretell just what he will find awaiting him when he turns a corner in the trail, or suddenly after a laborious climb emerges upon some mountain top, with the country spread out at his feet. So, the chemical explorer may suddenly stumble upon a wholly unexpected reaction, when in search of something else, as Perkin discovered Mauveine in the search for a quinine substitute, and the industry of synthetic dyes was born. Or he may reach a point from which he can begin to see, even if not clearly in all its details, a marvelous and close genetic and structural relationship, not previously suspected, between important groups of organic compounds. This has been realized just recently by the startling discovery that the morphine alkaloids; the resin acids; the heart poisons of the digitalis and strophanthus group; certain toad poisons; the sterols, bile acids and sex hormones; saponins; certain cancerigenic and estrogenic hydrocarbons; and one of the fungus pigments; are all derivatives of the well-known hydrocarbon, phenanthrene, which is found associated with anthracene in coal tar.

It is this same love of adventure which explains why so many scientists are ardent fishermen, hunters and lovers of the outdoor life.

Like every other human activity, chemical research

has its days of discouragement and depression. But do not believe that defeatist and hopeless saying that "opportunity knocks but once," for opportunity herself has said, in the words of Walter Malone:

They do me wrong who say I come no more,
When once I knock and fail to find you in;
For every day I stand before your door
And bid you wake and rise to fight and win.

CONSPICUOUS ASTRONOMICAL ADVANCES OF THE YEAR[1]

By Dr. HARLOW SHAPLEY
DIRECTOR OF THE HARVARD OBSERVATORY

A SURVEY of some of the most important or most interesting events in the astronomical world during the past year includes stories about the solar system, the galaxy of stars and nebulae and extragalactic objects. Some of these events were predicted, such as the total solar eclipse; others, like the epidemic of new stars, were unexpected.

(1) A new theory of the origin of the solar system —or perhaps it would be better to say a variation and extension of older theories—has been proposed by Dr. R. A. Lyttleton, an advanced student of astronomy at Princeton University. Dr. Lyttleton's hypothesis, which is born out of suggestions by Professor H. N. Russell, makes a decided advance in our speculation concerning the origin of the planets; for he has shown a way in which at least one of the most troublesome objections to earlier theories may be avoided. His theory, in brief, suggests that formerly the sun had a companion star. This companion, after being partially disrupted by the close passage of a third star, long ago deserted the neighborhood, leaving in the sun's gravitational care the debris of the creative encounter. The present planets, formed from the erupted filaments in much the manner described in earlier tidal evolution theories, are endowed with momentum derived from the parent star. The failure to account for the large angular momentum (velocity times distance times mass) of the individual planets has been the principal difficulty in earlier theories. Lyttleton's hypothesis is a step forward, but we must still admit that a completely satisfactory theory of the origin of the solar system does not exist.

In speaking of this problem, we should also point out that Professor Russell's new book on the origin of the solar system certainly can be considered one of the most important publications of the year.

(2) The total solar eclipse of June 19, observed from the Grecian Isles, through Russia and Siberia to the northern Japanese Islands, was the usual mixture of success and sadness. The Harvard–M. I. T. eclipse expedition to Ak Bulak was uncommonly successful, and hundreds of spectrograms were brought back. It will take years to discuss results fully, but preliminary examinations by Dr. Menzel and Dr. Boyce, the leaders of the expedition, show several new coronal lines, and indicate a close connection between high excitation in the chromosphere and the strength of the as yet unsolved coronal radiation. From his infrared eclipse plates Mr. Hemmendinger, of the Harvard expedition, finds a new strong coronal radiation at approximately λ 9800—much farther to the red than any coronal line heretofore known. The new information on coronal lines will greatly assist in the interpretation of the corona and the identification of its material.

(3) Two important additions to the powerful astronomical equipment of the western observatories have been announced. One is a twenty-inch astrophotographic telescope for the Lick Observatory; its four component lens system is designed by Dr. Frank Ross, and is now in the process of manufacture by J. W. Fecker at Pittsburgh. An eighteen-inch Schmidt type camera has been made in Pasadena for installation on Mount Palomar, near the site where the building is now under construction for the 200-inch reflector. The Schmidt camera, the largest of its kind now in America, combines the advantages of speed and achromatism characteristic of reflectors with the large flat star field characteristic of refractors.

(4) The discovery and exploration by Dr. Otto Struve and his colleagues at the Yerkes Observatory of a "red" nebulosity around the bright star Antares was announced at Harvard's Tercentenary Conferences. Nebulae which reflect light of blue stars, such as the Pleiades, have long been known. But this is an important advance in indicating the power of nebulosity to reflect light from red stars. A small Schmidt camera was useful in this research, which was carried on chiefly at the McDonald Observatory on Mount Locke in Texas.

(5) The past year has been conspicuous for a wave of bright novae appearing in the Milky Way. The records of astronomy show no similar frequency. Astronomers were still intent upon the peculiar Nova Herculis that appeared in 1934 when a dozen different observers, on the nights before and after the total solar eclipse, independently discovered the naked-eye Nova

[1] Remarks at the dinner of the American Association of Variable Star Observers, October 17, 1936.