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CHEMICAL IDEAS IN MEDICINE AND BIOLOGY[1]

By Sir HENRY DALE

DIRECTOR OF THE BRITISH NATIONAL INSTITUTE FOR MEDICAL RESEARCH

THIS is the second occasion within a period of some eighteen months on which I have been given the pleasant opportunity of taking part in the opening of new research laboratories in this country, supported by your great pharmaceutical industries. I hope I may detect, in this second invitation to take part in a ceremony of this kind, a willingness to regard me still as one of the workers in medical science who have found opportunity for research in laboratories supported by industry, although my work under such conditions came to an end all too many years ago. I shall never regret that experience, or cease to be grateful for the opportunity which it gave me. As I suggested when I spoke last year at Rahway, the immediate objective of research in such laboratories, and the kind of opportunity which it affords, may have their natural and proper differences from those of the laboratories supported by academic or public endowment. But the differences in result for the progress of medical science are often more formal than real; and it is my hope that the growth of cooperation between those working in these different spheres may yet bring to many the rather rare privilege which has fallen to my own lot of migrating from one to the other, and back again, and thus of knowing at first hand the best that each can offer.

We are opening to-day new research laboratories in connection with a modern pharmaceutical industry. To those of us who can look back over the period which has elapsed since my own student days, the change that has taken place in the scope of pharmacy has a revolutionary aspect. Forty years ago the earliest of the antitoxic sera ranked as recent discoveries, and accurate methods for measuring their activities in tests on animals had just been laid down by Ehrlich, on principles which provided the founda-

[1] Address given at the opening ceremony of the Eli Lilly Research Laboratories, October 11, 1934.

tion of all sound later work on the biological assay of remedies. The first effective application of a hormone in the specific treatment of a disease—that of thyroid extract in myxoedema—was still a novelty, and the remarkable activity of extracts from the suprarenal gland, due to the substance later isolated and named epinephrine or adrenaline, had just been observed. Pharmacy in those days was still predominantly concerned with the traditional drugs which had come into use through empirical observation; and the extracts and tinctures commonly used in practise could be and to some extent still were made on a small scale by the individual retail pharmacist. There was already, of course, some large-scale production even of these old-fashioned, galenical preparations, and a beginning had been made with the manufacture of an early few of the synthetic preparations which are now available in such bewildering multitude and variety. But the therapeutic practise of those days, to an extent which in retrospect from the present position seems almost incredible, was still based almost entirely on an empirical tradition; and, though new additions had from time to time been made to the *materia medica,* the therapeutic outlook and attitude had changed but little for centuries. A beginning had been made by pharmacology towards rationalizing the use of those of the drugs in common use which had an action sufficiently definite to be susceptible to experimental analysis. Towards most of the conventional range of treatment, however, the attitude of the candid physician, no less than of the experimental investigator, was one of sceptical pessimism. For a large proportion even of serious illness he prescribed medicinal treatment because the patient expected it, rather than with any hope of result beyond, perhaps, a minor alleviation of symptoms.

I am not suggesting that such expectant or palliative treatment no longer exists in medical practise or that its complete elimination is to be expected or desired. Alleviation of symptoms not only brings the richest reward of gratitude; it may be the most urgent medical duty. The change, however, towards a rational and fundamental therapeutics, aimed at removing causes or replacing deficiencies, has been, during the period in question, and is still in active progress. One example comes vividly and appropriately to my mind on the present occasion. As a student in the medical wards, I remember hearing a great physician, faced with a case of diabetes, express the view that it would have been better for the patient if his condition had not been discovered. "We can," he said, "at best prolong his life a little, and only at the cost of making it not worth living." The same, indeed, might have been said at any time during a further twenty years from that date; but, speaking in the presence of Sir Frederick Banting, and in the place where the large-scale production of insulin had its earliest organization, I do not need to remind you of the revolutionary change which has since taken place, with regard to the treatment of diabetes.

The transformation of the whole aspect of one disease by the discovery of insulin has attracted a more general attention than almost any other advance in medical science within our time. For those of us who have been engaged in experimental attempts to trace the complicated story of the functions, transformations and fate of sugar in the normal body, it has represented a physiological advance as important as that which it has effected in medical practise. Yet we may regard this discovery as one item of the wider progressive change in therapeutic method, based upon new knowledge of the causes of disease and aiming at the removal of those causes. Looking at the change as a whole, I think we may distinguish two main contributory factors.

(1) The first was the recognition of infections as due to the invasion of the body by living microorganisms. It is a commonplace that preventive medicine was born of this discovery, but the new knowledge, with its astounding and still progressive development, has also given a new direction to the therapeutics of infective diseases, in the search for remedies specifically killing or limiting the growth of the infecting microorganisms, or specifically neutralizing the poisons which they produce in the infected body. A few of the older remedies, indeed, owed their value to an unconscious application of such specific actions, for the control of infective organisms which modern research has since identified; but I can only think of some three or four of such specifically acting drugs which the old empirical pharmacy bequeathed to us—cinchona, ipecacuanha, mercury and the iodides. Contrast with this the resources of modern therapeutics, with its range of antitoxins and bacterial products and its growing list of new synthetic compounds discovered as the result of deliberate and organized search, for substances which shall be harmless to the infected patient in doses which kill or prevent the multiplication of the infecting organism—the new type of experimental therapeutics which Ehrlich termed "chemotherapy." But a few years ago, it might have been supposed that the relation between the bacterial constituents and the antibodies or natural antidotes, which the body itself produces to neutralize them, was of a complexity which put it beyond the reach of attack by the methods of structural chemistry. The position has been so changed, however, by the work of Landsteiner, of Avery and Heidelberger and of others, that it is hardly too much to say that a new and exactly chemical basis for these mysterious phenomena of immunity is even now being

built. Meanwhile, the synthetic production of artificial specific remedies for infection has, in the course of some twenty-five years, given us arsphenamine and other organic arsenical compounds such as tryparsamide; various derivatives of antimony; complex organic substances related to the dyestuffs on the one hand or to natural alkaloids on the other, and specifically effective against the trypanosomes of African sleeping sickness or against the parasite of malaria, still the most deadly enemy to human life and health, if we view the world's peoples as a whole. We may properly class these synthetic substances with the antitoxins and other anti-bacterial substances, as artificial and natural agents for the removal from the body of harmful invaders from without.

(2) A second principal factor in this change in therapeutic outlook may be found, I think, in the recognition of diseases due to the lack of substances normally present in the body, without which its normal functions and the normal development of its organs and tissues can not proceed. These substances, required in quantities which, in some cases, seem almost fantastically small, but none the less essential for healthy function, are of two kinds.

(a) The body has its own factories, in the glands of internal secretion, for the wide variety of principles grouped together as the hormones; and modern therapeutics can show no triumphs more brilliant than those which have followed the discovery of methods of preparing a number of these in a state of sufficient purity to enable them, by artificial administration, to correct an abnormal deficiency. We have spoken already of the first example in the treatment of myxoedema by thyroid gland substance, and of the dramatically successful correction of the diabetic defect by insulin. The thyroid treatment had involved few technical problems of preparation or administration, since the raw gland substance, given by the mouth in small doses, was already effective. In the case of insulin, the existence of such a pancreatic hormone, and even its origin from the islets of Langerhans, had been very probable for many years; but all attempts to prepare it and to apply it in treatment had failed. The influence of Banting and Best's great achievement, in showing that insulin could be obtained in stable solution and applied effectively by injection, went far beyond their immediate problem, in awakening new hope and initiative with regard to other hormones, which had appeared to be equally elusive. Tetany, Addison's disease, pernicious anemia have now all been brought within the range of specific treatment, by artificial supply of the defective hormones from the parathyroid glands, from the suprarenal cortex and from the stomach and the liver, by the brilliant work of Collip, of Swingle, Hartmann and their respective coworkers, and of Minot, Castle and their colleagues. Who can doubt that preparations from these glands are destined to acquire an increasing range and success of application, as the methods for purifying and stabilizing their subtle principles are progressively improved, and as clinical science, thus able to apply them, recognizes more clearly the conditions due to partial defects of their natural supply? I can not take time for more than a mere mention of the new vistas of knowledge which are being opened by the study of the complex interplay of the series of hormones controlling the physiological cycles of sexual activity and reproduction or by the daily unfolding of the multifarious activities of the hormones formed by one part only, the so-called anterior lobe, of the pituitary body, tucked away in a little bony recess at the base of the brain. Somebody has already bestowed on this tiny organ the picturesque title of "the conductor of the endocrine orchestra." And, indeed, there is no sign yet of any end to the revelation of new directions in which its hormones control the activities of other glands and their output of other hormones. Methods for obtaining in separate solutions the apparently different principles by which this pituitary lobe presides over normal growth and over the activities of the sex glands, and by which it acts in some kind of balancing antagonism to insulin, are already beginning to appear. It can hardly be doubted that some of them, with advances in the technique of their separation, are destined to play important rôles in practical therapeutics.

Let us note, further, for encouragement, how many of the hormones have already been prepared in chemically pure condition. In the case of epinephrine and thyroxine chemistry has gone much further than isolation; not only is their structure exactly known, but they can be prepared by artificial synthesis. In the case of one of the female sex-hormones the structure is already known with practical certainty, and synthetic production may be anticipated with some confidence. Insulin has been obtained by Professor Abel, and by others who have followed his lead, in crystalline form; though its complex, protein-like nature affords less hope for the elucidation of its structure. And now, only in the past few weeks, comes news that Dr. Kendall, of the Mayo Research Institute, who first obtained pure thyroxine, has succeeded in preparing what appear to be pure crystals of the elusive hormone of the suprarenal cortex.

(b) Then there is the second class of specifically acting substances, necessary like the hormones for healthy function and growth, but obtained by the body mainly from the food, and known to all the world as "vitamins." The story of these, of their successive recognition, still not completed, by the protective action of each against a different well-known disease of deficiency, such as scurvy, rickets, beri-beri, pellagra, provides, like the story of the hormones, one of the romances of recent medical research. It is related of Jaques Cartier and his expedition, when they landed in Canada four hundred years ago, that, being attacked by scurvy, they learned from the native Indians to cure the condition with an infusion of the fresh sprouting tips of a species of fir tree. Nobody can guess how long the Canadian Indians had possessed this life-saving knowledge, just as those of the South American Continent knew of the value of cinchona bark in fevers and of ipecacuanha in dysentery. This method of treating scurvy, however, passed out of the white man's memory for yet another two centuries. A more extended knowledge of the relation of scurvy to lack of what is now called Vitamin C, and even of the kinds of food containing the missing factor, again became available in the eighteenth century, from the experience of Scandinavian and British sailors and explorers. Captain Cook's voyages of discovery in the good ship *Endeavour,* to the islands of the Pacific, to New Zealand and Australia, owed their success largely to the scientific measures which he took to protect his crews from disease and particularly from scurvy. I take some satisfaction in noting that the Royal Society of London, when giving to James Cook the Copley Medal, the highest honor at their disposal, based the award, not on his great geographical discoveries, but on his improvement of methods for preventing disease among sailors. Yet we had to wait till the present century for a study of diseases due to such qualitative defects of diet, as an important branch of medical research, and the systematic, experimental study of such defects, by the use of artificially compounded diets, began only a little over twenty years ago. Six at least of these vitamins are already known as separate entities, with the special disease or functional defect, produced by the absence of each from the diet. The chemical nature of three or possibly four of them has been clearly established; two at least of them, Vitamins C and D, have been artificially prepared in a state of complete purity. Here again, a whole vista of new possibilities has opened, for the scientific treatment and prevention of diseases which, but a few years ago, presented a baffling series of problems to medical practise. Some applications have become, in a literal sense, household words. When a few years ago my colleagues at the National Institute for Medical Research, in London, obtained a pure, crystalline Vitamin D, and gave it the chemical name Calciferol, it was desirable to show, by actual trial in the clinic, that this intensely active substance had a curative action on rickets in children, as well as on experimental rickets in rats. London was searched in vain for suitable cases of rickets, in which the good mothers had not already begun treatment with cod-liver oil, before presenting the little patients for examination; and we had to go further afield, to an area of extreme industrial depression, before the action of Calciferol could be demonstrated on cases not previously treated. Again in the case of the vitamins, it seems probable that scientific application in medicine is only just becoming a possibility, now that their separate preparation enables the action of each to be individually studied, and the results of its deficiency to be more clearly recognized and disentangled.

It would be possible to regard this remarkable change in therapeutic outlook and method simply as one phase in the general scientific development which has transformed a whole range of human activities in a generation. If we look, however, for a particular rather than a general cause, I think we shall find it in the rapidity with which chemical knowledge and ideas have, in this same period, permeated the whole of medical and biological science. Forty years ago, though chemical research in the domains of physiology and pathology had representatives of high distinction, the orthodox chemist was often ready to ignore their activities, or to rank them as a pretentious type of cookery. To-day biochemistry has long taken rank among the great divisions of science, and its influence penetrates the whole range of the medical and biological sciences, while organic chemistry itself is showing a welcome tendency to recover its original objective, in studying the products and processes of living organisms. Pathology, immunology, physiology, have come more and more under the discipline and the stimulus of chemical ideas; zoology and botany concern themselves more and more with function, in terms of chemical changes and chemical stimuli; and the study of nutrition has ceased to think of diet only in terms of the main builders of the body's fabric and the direct sources of its energy, and has devoted itself with increasing enthusiasm and success to identifying the minute qualitative factors, specifically influencing metabolism and function, such as the vitamins and the rarer mineral constituents. The remarkable development in the scope and aims of chemical therapeutics has been a natural concomitant of this rapid chemical orientation of medical science.

It may be of interest to take a brief glance at some of the current expressions of this general tendency, in fields of investigation which lie as yet outside the range of practical application in therapeutics.

A few years ago it was customary to speak of the body as coordinating its activities by means of two forms of communication—by messages transmitted by physical changes through the nerves and by chemical messengers or hormones carried by the blood. These have been picturesquely described and contrasted as the telegraph and postal services of the body. Apart from the true hormones certain other highly active chemical substances have become known, widely distributed in the tissues, and taking part in local regulation, of the blood-supply especially. It has also been known for some years that the nerves belonging to a certain system, which controls the involuntary activities of the viscera, the heart and the blood vessels, do not exercise this control by a direct transmission of the physical impulses passing along them to the organs in which they end, but by liberating potent chemical agents, by the action of which the effect of the nerve impulses is transmitted. Two such agents were recognized, transmitting the largely antagonistic effects of different groups of these nerves. One of them has been almost certainly identified as acetylcholine—a substance of which the intense activity was first recognized by Professor Reid Hunt nearly thirty years ago, and in which I also became interested at an early stage, long before we had any reason to believe that it occurred in the body or had any important natural function. Loewi, who gave the first clear demonstration of this chemical transmission of nervous effects, recognized the close similarity to acetylcholine of the substance liberated in the frog's heart by impulses in the vagus nerve; and the evidence for this identification grows almost every week. The other substance, which has recently been studied especially by Professor Cannon, transmits effects of nerves of the so-called sympathetic system; and its actions and such of its chemical properties as it has yet been possible to test suggest a close similarity to epinephrine or adrenaline, so long known as a hormone from part of the suprarenal gland. To take one example, the rate and force of the heart beat are controlled by impulses reaching it through two different nerves, those from the vagus nerve making it slower and weaker, while those from its sympathetic nerve make it quicker and stronger. It can now be stated definitely that the vagus impulses produce their effect by liberating acetylcholine, and that the sympathetic impulses produce theirs by liberating something like adrenaline, among the fibers of the muscular wall of the heart.

So far the main lines of the picture have been clear for some years; but during the year now ending it has undergone a rapid extension and development. Acetylcholine, in particular, is acquiring an importance in the physiology of the nervous system far beyond any that could have been predicted. We already have evidence that, at every point in a nerve ganglion where a nerve fiber ends in contact with a nerve cell, transmission of the effect of an impulse from one to the other is effected by liberation of a tiny charge of acetylcholine. We can even estimate the order of the amount—of the weight of acetylcholine used to transmit the effect of a single nerve impulse to a single ganglion cell; but, if I give the weight in grams, I shall have to ask you to imagine a row of 20 noughts to the right of the decimal point before you reach a significant figure (10^{-21} gram). We have further evidence, less complete but highly suggestive, that every ordinary motor nerve impulse, to a fiber of our voluntary muscles, similarly produces its effect by liberating a little charge of acetylcholine in contact with the receptive plate of the muscle fiber, thus stimulating it to contraction. As I speak to you, I have every reason to suppose that the muscle fibers of my tongue and my jaws are being activated by innumerable little charges of acetylcholine, fired at them, as it were, from the endings of the nerve fibers.

For the whole of the peripheral nervous system, then, we seem to be in sight of knowledge enabling us to describe the transmision of effects, from nerve fibers to receptive cells, in terms of precise chemistry. And the vast and complex problem of the central nervous system still remains. It will be strange, indeed, if knowledge of this kind, expanding just now with such unexpected rapidity, does not eventually have some effect, if only an indirect one, on practical therapeutics.

Let us glance at an entirely different field of research. We have spoken of the pure crystalline Vitamin D, a sterol derivative which my colleagues have called Calciferol, and of the isolation of pure hormones concerned with the control of certain sexual functions. At least two of these have been crystallized and studied in pure condition, one concerned with female function, the other with the maintenance of the general characteristics of the male; and the general lines of structure of these substances have been established, so that it is not unlikely that one or the other may at any time be produced synthetically by some ingenious chemist. Perhaps it is not altogether surprising to learn that these sex hormones appear to be closely related compounds, differing from one another in detail rather than in general plan, though we are very far from understanding how so small differences of structure can produce so large a difference in physiological character. In the pattern of both we can trace again a central structural arrangement which, in the last few years, has been recognized as common to the group of the sterols, for long regarded as peculiarly inert constituents of the body. And now, within a few years, we find related to them, on the one hand, the vitamin D, on the other these sex hormones, all of them substances of intense physiological activity, but producing effects of entirely different kinds—surely a relationship which is sufficiently surprising. Yet there is another even less to be expected. Habitual contact of the skin with tar has long been known to cause a liability to superficial cancer; and the condition can be produced experimentally in animals by frequent tar painting. Dr. Kennaway and his coworkers in London have for years been engaged in the difficult quest for the constituents of tars which produce this effect. And when at length they succeed, the substances they find have again a type of structure suggesting the central nucleus of the sterols, linking them with sex-hormones on the one hand and Vitamin D on the other. Induction of cancer with prolonged application to the skin, prevention and cure of rickets, provocation of sexual function and development—here is a curious assortment of activities to be linked by a central chemical structure, common to the substances producing them, and to the inert sterols as well. Nor is the community merely the theoretical one of chemical structure. The specific activity characterizing one or another of these, when it is given in tiny fractions of a milligram, may apparently be shown by the others when given in relatively large amounts. Thus, we have evidence that a substance which, when painted on the skin, causes a cancerous growth to appear, will also cause a capon to change its plumage for that of a normal hen, when injected in a suitable dose; while the same carcinogenic substance, or even the pure Vitamin D, if injected in relatively large amounts into female rats, will initiate a cycle of sexual activity. The chemical approach is leading us to some curious associations.

If we follow the story of this chemical induction of malignant growths a stage further, it leads us to an association still stranger and more mysterious. Years ago Rous of the Rockefeller Institute described the first of a series of malignant tumors in fowls, which had the property that its filtered juice, free from all cells and visible organisms, would cause a similar tumor to form in another fowl into which it was injected. A number of such tumors have since been described. And now, quite recently, comes the news that injection of some of these tar products into a chicken will cause a tumor to be found, and that a filtered extract from this tumor will reproduce its growth in other chickens, from which it can again be passed by filtrates in apparently endless propagation. Now the filtrates of these tumors have all the properties of living infective agents, not of chemical irritants. In a number of different ways they are allied to the viruses, the study of which, as the causes of many of the most important infective diseases, has progressed so rapidly in recent years. The study of the visible bacteria had left, as the great outstanding problem of infective pathology, these infections transmitted by materials in which no organisms could be cultivated or seen—smallpox, infantile paralysis, measles, chicken-pox, mumps, yellow fever, influenza, the common cold, dog distemper, foot and mouth disease, and many more. Recent work, on both sides of the Atlantic, seems in the case of some of them, such as psittacosis and vaccinia, to have succeeded in demonstrating bodies like extremely minute organisms, so small that they were beyond the range of the microscopic methods previously available. There is a whole series, however, with infective particles of diminishing size until, as in the case of the virus of foot and mouth disease, they approach the dimensions of protein molecules in solution. They are not chemical agents in the ordinary sense, but it is difficult to picture them as organisms. The agents transmitting bird tumors fit into this series in many of their properties. Are we to picture them as lying in wait in the normal tissues, for some failure of their resistance, such as the tar substance might produce, to give them a foothold? Or does the chemical irritant produce some perversion of metabolism which starts the cell on its malignant career, the perversion being transmitted to the direct offspring of its cleavage, or even to normal cells by contamination with its juices. That is a statement, with the crudest brevity, of what appears to be the central problem, common to the study of the malignant tumors and of many of the infections due to acknowledged viruses.

We have turned aside for a hurried glance at the course of medical research at certain points where it is advancing freely into the unknown, where therapeutic application must probably wait till the fundamental structure of knowledge has been built and where hope for the future is more justified than action in the present. Our earlier survey, however, of the fields where therapeutic practise has been able to follow the expansion of knowledge more closely, presented us with a sufficiently imposing list of new types of scientific remedies—antitoxic sera, bacterial vaccines and antigens; artificial chemical antagonists to different infections; hormones which the healthy body makes in its own glandular laboratories; vitamins which it obtains ready made, or as raw materials for its own further elaboration, from natural, unsophisticated foods. We have made no mention as yet of the newer symptomatic remedies, the array of new substances synthesized in the laboratory or extracted from natural sources, for the relief of pain or the artificial stimulation of some flagging natural function. And what do all these new developments mean for pharmacy? They have but little relation to the art of the individual pharmacist whom our fathers knew, compounding his pills and potions among the jars and bottles of the dispensary. We must resign ourselves, I fear, here, as in other spheres of human activity, to the loss of an individual art in exchange for scientifically organized production.

Pharmacy, indeed, to meet these novel, various and expanding demands of modern therapeutics, has to become one of the most highly organized departments of scientific manufacture, covering an extraordinary range of expert knowledge and equipment. It now needs stables and pastures; incubation rooms for the large-scale culture of a wide variety of bacteria, and sterile rooms for manipulation of the products; chemical plant adapted to the difficult synthesis of complex and delicate compounds, or to the chemical and physical separation and purification of unstable natural principles, from animal organs only obtainable in adequate quantity and freshness by the cooperation of highly organized abattoirs. But there is a much more fundamental requirement. It is not organization, however perfect; it is not expenditure, however lavish, on manufacturing equipment; it is not even the services of a staff of highly qualified experts for the routine conduct and control of manufacturing operations, which will enable a pharmaceutical enterprise to meet the changing and expanding needs of modern therapeutic practise. It can not hope to do this, unless its activities respond to the stimulus and submit to the guidance of continuous and progressive research. And when I speak of research, it will be understood that I do not mean merely experiment directed to improving the technical methods of manufacture or the control of its products, though there is need and scope for work of high scientific quality in these directions. I mean research undertaken in a spirit of free inquiry, often with no immediate practical aim, or any probable result, other than the increase of fundamental knowledge. American industry has a noble record of the direct support of such fundamental research, and Dr. Langmuir's presence provides this occasion with a direct example and representative of this enlightened policy. Eli Lilly and Company, also, have claim to high rank among the industrial organizations which have supported scientific research for its own sake. Numerous laboratories in this and, indeed, in other countries, have reason to be grateful for their generous and well-directed aid. As for their support of research within their own organization, I recently visited the Marine Laboratory at Woods Hole, and there saw Dr. Clowes and some of his staff, who had been working through the summer on problems of fundamental biology, in happy association with distinguished academic workers in the same field; and I brought away with me the conviction that there was no need here to urge on an enlightened directorate the claims of research having no immediate or visible relation to its business, but of immense value in keeping alive the scientific initiative and mental enterprise of those who also serve its interests more directly, and in helping them to establish and to retain their proper rank in the great scientific fellowship. It is because we know that Mr. Lilly and his co-directors, while free and generous in their support of medical and biological research in many laboratories and in many countries, have had the wisdom to give to their own scientific coworkers a wide freedom in the scientific field, and have known how to value the spirit which it engenders, that we take part with such pleasure in the inauguration to-day of these splendid research laboratories. We do so with high hopes for the use which Dr. Clowes and his distinguished staff of collaborators will be able to make of this greater opportunity, for their own advancement in the great commonwealth of research, for the advancement of the great and progressive industry which has provided the opportunity, and, above all, for the advancement of medical science in the interest of all mankind.

PROGRESS IN DEVELOPMENT OF THE U. S. WEATHER SERVICE IN LINE WITH THE RECOMMENDATIONS OF THE SCIENCE ADVISORY BOARD

By WILLIS RAY GREGG

CHIEF OF THE UNITED STATES WEATHER BUREAU

The Science Advisory Board, which acts under the jurisdiction of the National Academy of Sciences and the National Research Council, was created by order of President Roosevelt on July 31, 1933. This board was given authority "to appoint committees to deal with specific problems in the various departments." One of the first committees so appointed was the "Special committee on the Weather Bureau." Its members are: Robert A. Millikan, director, Norman Bridge Laboratory of Physics, and chairman of the Executive Council, California Institute of Technology, Pasadena, Calif., *chairman;* Isaiah Bowman, chairman, National Research Council, and director, American Geographical Society, New York City; Karl T. Compton, president, Massachusetts Institute of Technology, Cambridge, Mass.; Charles D. Reed,