velopments with two crop plants, the bean and wheat, each of which has received especial attention from professionals skilled in both pathology and genetics.[2]

With the bean, our practical progress to date in developing disease-resistant strains is based upon the chance discovery of two basic types by men who were neither pathologists nor geneticists. I refer to the anthracnose-resistant strain, the Wells Red Kidney, found in his fields by a New York bean grower, Luce, (later grown by Wells), and the comparably chance discovery of the first mosaic-resistant Robust bean plant by Spragg, of the horticultural staff of Michigan Agricultural College. Although we may flatter ourselves by the thought that Professor Spragg was a member of our professional group we should recall that neither he nor any one else knew bean mosaic when he made that "find" in 1908. This "robust" plant was selected for general vigor and yield rather than for recognized disease resistance.

In the search for wheat resistant to the stem rust, unless I am mistaken, the strains of outstanding promise to date are the Kanred and the Webster. The Kanred came from selections originating with an imported Crimean wheat and continued by the Kansas College staff a decade before its rust-resistant character was defined. The Webster descended from another strain of Russian wheat introduced by the U. S. Department of Agriculture in 1913. This was of so unpromising a type that it was not even given a name until a seed grower, E. S. McFadden, of Webster, South Dakota, chanced to observe its rust-resisting character. Stakman[3] and associates, in following up this lead, find that the Webster wheat is "resistant to more physiologic forms of *Puccinia graminis tritici* than any other common wheat yet tested in the United States," and that it may be correspondingly "potentially valuable as a parent of rust-resistant hybrids."

The moral seems to me obvious, not that we of each professional group should do less, but that after doing all that is rightly possible, we should clearly recognize, define and advertise the need for help from others, including the amateur and commercial groups.

But, having thus portioned responsibility, let us in closing again emphasize that any suggestion of such division of the field or sharing of the tasks is worse than useless and may be positively harmful if conceived in a spirit of inhibition. Individual initiative and personal freedom must always be stimulated rather than suppressed. It is here that we need constantly to recognize the artificiality of our academic departmental lines. Not only should the aid of the amateur be welcomed by our professional groups, but within our professional ranks we must encourage the amateur spirit not merely as exemplified by enthusiastic devotion of purpose but also as concerns freedom to follow the natural leads of the problem. The finding of a disease-resistant plant by the horticulturist or the geneticist must bring opportunity with responsibility for continuing attention to the associated pathological questions as well as to those distinctively genetical or horticultural. Similarly, if the initiative is from the pathologist, he must give earnest attention to the genetical and cultural aspects if his contributions are to be at once fundamentally sound and practically worth-while. The methods of correlation must vary with each case. Ideally it may seem the commendable thing for two or three men representing specialized groups to work in association. Practically I believe the preferable way is for the one who initiates the work to carry it as far as he may, regardless of professional relations. If he starts as a plant culturist, whether professional or amateur, let him be encouraged and personally aided by pathological or genetical associates to penetrate and work in their field as far as justified by the natural trends of the problem and his ability to follow these. The spirit of research must not be restrained by the artificial bounds of professional or administrative classifications. The only criteria should be the genius to initiate and the ability for sustained progress in a natural course. In this way is the conquest of nature to proceed with disease resistance as with every other type of scientific endeavor.

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[2] It may not be inappropriate to add that the case of Fusarium resistant cabbage, to which we have given especial attention, might also be cited. Our own findings of disease resistance in cabbage were antedated by two horticulturists, and at least one practical grower. They did not, however, know the nature of the disease and confused it with the bacterial black rot.

[3] Stakman, E. C., Levine, M. N., and Griffee, F. Webster, a common wheat resistant to black stem rust. *Phytopath.*, *15*: 691, 1925.

CHEMISTRY AND PURE SCIENCE[1]

The wide field embracing the so-called natural sciences, ever broadening, ever extending its frontiers, may be conveniently and somewhat indefinitely divided into two general areas. One of these areas includes the descriptive sciences, and the other the explanatory sciences.

A descriptive science deals with the problem of investigating and describing various objects or phenomena as they occur in nature, while it is the aim

[1] Address delivered on the occasion of the dedication of Venable Hall of Chemistry, at the University of North Carolina.

of explanatory science to investigate the genesis, the inter-relations and the transformations which spontaneously appear or can be produced artificially, and to endeavor to discover the causes of these changes.

To quote from Mellor:

> It is the popular belief that the aim of science is to explain things; as a matter of fact, the so-called explanations of science do not get much beyond describing the observed facts in the simplest possible terms so as to make their relations with one another clear and intelligible.
>
> Science may explain a phenomenon by describing how one event is determined by an antecedent action—sometimes called a cause; and how one particular set of conditions—the cause—can give rise to another set of conditions—the effect. Science explains a phenomenon (the effect) by showing that it is a necessary or rather a probable consequence of another phenomenon (the cause).

If we attempt to assign any given branch of science to either the descriptive or the explanatory region of the general field we meet with difficulties which at once become apparent, for there is practically none that is wholly descriptive and none that is wholly explanatory. That this difficulty of classification should exist is apparent from the very nature of science itself, for, to quote Huxley:

> All true sciences begin with empirical knowledge—the record of facts obtained by observation and experiment.
>
> It is work for the intellect to educe the elements of sameness amidst apparent diversity, and to see differences amidst apparent identity.

In other words all science begins with facts and ends with laws.

Chemistry, therefore, can be expected to offer no exception to the general rule, for it is man's attempt to classify his knowledge of all the different constituents which compose the natural objects in the universe. It is therefore a fundamental portion of descriptive science. But it is—moreover—an explanatory science, since it attempts also to afford an explanation of the phenomena which occur when the different kinds of material react one with another. It strives also to give an insight into, and an understanding of, the very constitution of matter itself—something at present entirely, and probably forever, beyond the direct grasp of our senses. In all cases it has been necessary to first investigate that which is visible and subject to direct observation by the organs of the senses and then to develop hypotheses or propositions as to the actual causes and the true nature of the relations which have been observed between that which has been studied and the categories of time, space, movement or mass. It has further been necessary to verify the logical consequences of these hypotheses by experiment, and to advance theories which shall account for the nature of the properties of the thing studied in its relations with things already known, and with those conditions or categories among which it exists. And finally it has been necessary to keep clearly in mind a fact which is far too often overlooked or forgotten; a hypothesis or a theory can neither be proved or disproved. To quote the words of Ostwald, "It is merely a tool which is rejected when found to be no longer serviceable."

To briefly recapitulate we may therefore say that chemistry is the science which investigates and describes the various materials of which all natural objects are composed; it attempts to explain their actions toward other substances by indicating the causes of their behavior, and it offers hypotheses and theories to explain the behavior of substances when the causes are not directly perceptible to the organs of sense.

The more advanced developments of chemistry are indistinguishable from the science of physics and no dividing line can be drawn between the distinctive fields of these two important branches of natural science.

If we attempt to distinguish between a pure and an applied science we encounter difficulties which are even more formidable than those met with in an effort to distinguish between a descriptive science and an explanatory science, or to distinguish properly between physics and chemistry. "Pure" science may be defined as knowledge sought solely for the sake of truth, and applied science as knowledge utilized in the practice of the various arts. But if we go back to the earliest authorities and consult Plato and Aristotle we may be somewhat embarrassed to find it explicitly stated that—"It is the purpose of pure science to observe phenomena and trace their laws; the purpose of art to produce, modify or destroy. Strictly speaking there is no such thing as applied science, for, the moment the attempt is made to apply, science passes into the realm of art."

Since my thesis is the relation of chemistry to pure science I am in no way embarrassed by such a summary elimination of a topic which it is the duty of others to defend. But such an elimination in no way accords with the profound regard and respect which is felt by all for applied chemistry as a most potent factor in alleviating the suffering and improving the lot of mankind.

The contributions of chemistry to pure science in the strictest sense of the term have been so conspicuous and so great as to require neither enumeration nor emphasis. A list of the names of eminent chemists would be a list of conspicuous contributors to the advancement of science in its purest form. Lavoisier, Dalton, Davy, Berzelius, Bunsen, Van't Hoff, Arrhenius, Victor Meyer, Crookes, Remsen, Venable—their names are many and they have labored for the truth in science and for the truth alone.

To cite a conspicuous example, because of his notable genius and because of the fact that, being associated with the university at which I was at that time a student, it was my privilege and pleasure to have known him—I will refer to Josiah Willard Gibbs. Gibbs contributed more than any other scientist to the elucidation of some of the most complex problems in theoretical chemistry. He was a pure scientist if there ever was one. He was absolutely impractical and the application of his science to a practical problem of production would have been for him an utter impossibility. To him the pursuit of knowledge was an abstraction, something to be followed for the sake of the knowledge alone, without any ulterior view to its ultimate application. His studies were so abstruse and apparently intangible that he was understood by but few, if any, of his contemporaries and by only a small proportion of his more advanced students. But the value of his contributions to the realm of chemistry is well-nigh incalculable and his name is achieving the eminence to which it is entitled.

But although Gibbs and the many others who have added much to pure science through the medium of chemistry are dead—the progress in these directions will continue and new hands will bear the torches into the dark places.

It is in the realization of such dreams as the construction of this splendid laboratory which we are today dedicating that assures the fulfilment of the promise of the future, and, in closing, I will quote to you a remark once made to me by Willard Gibbs, which emphasizes an idea that may well serve as a guiding principle in scientific inquiry:

> Nature is like a sphynx of whom we are forever asking questions. The answer she gives does not depend so much on the questions we ask as it does on the way we ask our questions.

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OPENING OF THE ASTRONOMIC HALL OF THE AMERICAN MUSEUM

ON March 24, 1926, a reception was held at the American Museum of Natural History in celebration of the opening of the preliminary astronomical hall. Included in the exhibits are oil paintings of the three solar eclipses seen in the United States in 1918, 1923 and 1925.

These eclipse paintings were begun through the engagement of Mr. Howard Russell Butler, N.A., by Mr. Edward Dean Adams, to paint the solar eclipse of June 8, 1918, at the station of the U. S. Naval Observatory at Baker, Oregon, and the gift of this painting to the American Museum. A physicist by early training and an artist by life training, Mr. Butler is probably the best qualified man in this country, if not in the world, to undertake the painting of this astronomical phenomenon which lasts at most only a very few minutes.

The paintings are arranged in the form of a triptych, and one sees the paintings as he would view the eclipses, each through a separate window. The lights are hidden so that the pictures appear to be large photographic transparencies in their true color.

The picture on the left of the triptych is of the total eclipse of the sun, which occurred on June 8, 1918, as seen by Mr. Butler at Baker, Oregon. The eclipse reached totality at 4:03 P. M. at an altitude of about 45°, and since it was in the afternoon the long axis of the corona was inclined to the right. The time was near the period of maximum sun-spots, and as was to be expected there was a diminished corona not exceeding three fourths the diameter of the sun, but with more polar streamers than were expected. The prominences, especially those on the lower right, reached exceptionally large proportions, the "Heliosaurus" measuring 47,000 miles in height. The "Eagle" at the top was another large and striking prominence. The eclipse was seen through a thin film of clouds, so thin that it did not appreciably lessen its brilliancy, but added to the picturesque effect. (Gift of Mr. Edward Dean Adams to the American Museum of Natural History.)

The vertical picture in the center of the triptych is of the total eclipse of the sun, which occurred on September 10, 1923, as seen near Lompoc, California. This eclipse reached totality at 12:59 P. M. and since it was almost a noon-day eclipse, the long axis of the corona was practically horizontal. The time was nearer the period of minimum sun-spots, and as was to be expected the corona was more extended. It was seen in a gap between two clouds. Mr. Butler, having practically finished his notes during the period of totality, was surprised by the first Baily's bead of the third contact, that is, the first appearance of a speck of the photosphere, evidently between two volcanic peaks on the rough surface of the moon. This appeared like an orange ball of great brilliancy resting on the upper limb of the moon. For a few seconds the corona remained, and Venus, slightly more than one degree above the moon, continued to shine brilliantly. He concluded to make this combined effect, commonly known as the diamond-ring effect, his pic-