world. It is quite impossible on this occasion to discuss this philosophical tenet which has so large a number of followers, but I think you will agree with me that careful scrutiny of the very history of alchemy shows that it does not support this doctrine. Astrology, to which alchemy belonged, attempted to prescribe to nature the laws which it should follow, laws which, developed in detail, were expected to govern the mutual relationships between metals and planets, between microcosmos and macrocosmos, etc. But nature did not consent to be governed by these laws, and generations of thinkers could not impress them upon her. But when the chemist, following the example of Boyle, abandoned the idea of establishing laws *a priori* and entered upon the experimental study of natural phenomena, the way was opened for the successful development of chemistry. And thus we see that in contrast with the philosophical standpoint mentioned above, the history of chemistry can only strengthen our belief that the laws of nature are independent of the human mind in their existence, not in their conception, a belief shared since antiquity by some schools of philosophy.

We must therefore regard the return of modern science to the old ideas of the Greek philosophers as a sign that they have correctly realized a principle which was formulated in different ways during the development of science and which Kepler worded as follows—"Nature likes simplicity." This term "simplicity" does not mean that nature always acts in the simplest manner that can be imagined. Kepler's own example serves to demonstrate this. The astronomical system which he developed and in which it was assumed that the planets revolved in elliptic orbits is infinitely more simple than the old one which it replaced, but elliptic orbits are not the most simple that we can imagine: circles would be still simpler, but the planets do not rotate in circles. The same considerations hold as regards the idea of primordial matter. Strictly speaking, we do not now think that there is one primordial substance but rather that there are two. The atom of hydrogen consists of both positively and negatively charged particles, protons and electrons, and it now does not seem probable that we will reach a simpler view of this structure. But the general tendency of the Greek philosophers, especially of those belonging to the Atomistic School, to remove complexity as far as possible and to assume quantitative differences instead of the qualitative ones we must regard as a sound principle of natural philosophy throughout the ages. Therefore, if modern and ancient alchemy are very closely in agreement as to the existence of a primordial matter, this should be regarded not as a mere accident nor as an impress of human ideas upon nature, but as a distinct evidence that from earliest times eminent thinkers have rightly conceived the unity in the multiplicity of things. The greatest significance of modern alchemy is that it has enormously strengthened this early conception and has furnished convincing proof of the unity of the material universe.

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A SUGGESTED COURSE IN PLANT PHYSIOLOGY

LEPESCHKIN,[1] in his recent book "Pflanzenphysiologie," states that plant physiology can only further develop hand in hand with physics and chemistry. Van't Hoff[2] also recognized the dependence of one branch of science upon another. He represented this relation of the sciences by arranging them in order of their increasing complexity—mathematics, physics, chemistry and biology. The rapid development in the last few years of new and more exact methods in physics and chemistry makes this relation appear much more important than it did a generation ago. Thus a student who endeavors to further the development of plant physiology must be prepared in the fundamental principles of at least three branches of science. Under the system of prescribed work common in most American universities, a student has little opportunity to get more than the required courses for a major in one department and a minor in another. The prerequisite for plant physiology as found in all university catalogues is elementary botany. An examination of the catalogues of thirty-three of the larger universities and colleges offering courses in plant physiology shows the following:

No prerequisites in physics or chemistry	14
Elementary physics or chemistry desirable or required	19
Required chemistry or physics beyond an elementary course	0

When one considers the complexity of physiological problems, it is evident that the preparation of students for progressive work in plant physiology is quite inadequate. Experience with advanced students of botany extending over a period of six or seven years has shown that only the exceptional ones have the ability to do experiments accurately which involve simple physical and chemical methods. If we admit the truth of Lepeschkin's contention, it is difficult to foresee a rapid development of plant physiology as a

[1] Lepeschkin, W., "Pflanzenphysiologie," Vorwort, 1925.

[2] Van't Hoff, J. H., *Zeit. für Anorganische Chemie*, 18, p. 1, 1898.

branch of the natural sciences, until plant physiologists are properly trained.

The lack of adequate preparation of those doing research is reflected by the lack of data and information determined by modern physical and chemical methods in recent text-books on the subject; also by repeated appearances of data and information which are either incorrect or misleading, without proper criticism. This is particularly true for the subject of photosynthesis. A few specific examples will serve to support the above statement. Books on plant physiology by Palladin,[3] and Lepeschkin,[4] give the results of experiments to show the relation of the rate of photosynthesis to the wave-length of light. These experiments have been determined by means of prismatic spectra. The student is naturally led to believe that the relation in such a spectrum is the same as would occur in the incident light. This, doubtless, is not true because the intensity per unit area for the different regions in the spectrum is affected by the index of refraction, which is a function of the wave-length. We realize that information is often given for its historical value, as, for example, Engelmann's classical experiments, but in such cases criticisms are essential; or it should be accompanied by corrected information, according to the latest knowledge. Such criticisms and information have appeared only recently in Benecke and Jost, "Pflanzenphysiologie."[5] A similar interesting illustration is given by Palladin,[6] in which the correlation is shown between the rate of photosynthesis as determined in a prismatic spectrum and the energy distribution in a normal spectrum which was determined with a diffraction grating. This relation is purely accidental as far as the data are concerned, because we know that the maximum in the normal solar spectrum is in the red end in the morning and evening and in the blue end at noon, especially in the summer time. This is evident from the change of color of the sun in the morning and evening as compared with its color at noon, also from astronomical data.[7] Thus it would be quite possible to get a curve of the energy distribution of sunlight which would show a correlation with almost any curve showing the rate of photosynthesis. If the former curve had been corrected by calculation to what it would have been in a normal spectrum, there would then have been no correlation in the two curves. Further, this correction can not be made by dividing the rate of photosynthesis by the width of the absorption band.[6]

Again, Figure 35 in Lepeschkin's "Pflanzenphysiologie," showing the path of light in a prism is inaccurate in that the lines do not show the breaking up of the incident light into its component parts, and the points of focus where only a pure spectrum can at all be obtained, as is represented in elementary text-books of physics.[8] This is an important point which has been overlooked by many text-book writers on plant physiology, and hence inaccurate information is passed on to the students. It is very evident that many of the data on this subject have been determined with no attention paid to the purity of the spectrum used.

The lack of essential critical suggestions is also common in chemical data. It is well known that chemical analyses of plant material vary considerably with the method used, yet, in text-books, data are given to illustrate a point with no suggestion as to the method used or its accuracy. On account of such information as this, many students are slow to free their minds of the impression that if a fact is printed it is necessarily true or exact. Likewise, they are also slow in acquiring the ability to analyze critically experimental evidence and to form their opinions with impartial judgment, which is so essential in scientific work. Many investigators who are doing plant physiological work have been systematically trained in chemistry and have acquired their botanical training when the occasion demanded, or they have been systematically trained in botany and acquired their chemistry and physics. Under the present system of required schedules common in most American universities, it is often necessary for students of botany doing research work in plant physiology to stop their investigation to acquire the technique of the physical and chemical methods required for their problems. We have observed numerous instances where only the routine manipulations of ordinary physical and chemical methods applied to plant physiological problems have been learned, with no understanding of the principles underlying the use of these methods, the experimental errors, the degree of accuracy, and so forth. When students do not thoroughly know the principles upon which the methods depend, it is nearly impossible for them to adapt the methods to new conditions or to offer constructive criticisms.

As a remedy to these conditions, many have advocated cooperative research by individuals prepared

[3] Palladin, V. I., "Plant Physiology," Eng. Trans., p. 23, 1923.

[4] Lepeschkin, W., "Pflanzenphysiologie," p. 116, 1925.

[5] Benecke, W., and Jost, L., "Pflanzenphysiologie," 1924.

[6] Palladin, V. I., "Plant Physiology," p. 24, Fig. 15, 1923.

[7] Abbot, C. G., and Fowle, F. E., Ann. Astr. Obs. Smithson. Inst. p. 104, 1908.

[8] Stewart, O. M., "Physics," pp. 665–667, Ginn and Co., 1924.

in different branches of science. Such cooperation has often resulted in many discoveries which might otherwise have been impossible. It does not, however, remove the lack of appreciation of viewpoints held by investigators trained in different branches of science. This appreciation is obtained by a systematic and intelligent course of study. Also, such cooperation is often impossible, particularly for research students in different departments. Too often much time is wasted by the individual in pointing out the mistakes and the shortcomings of the other, without helpful and constructive criticism.

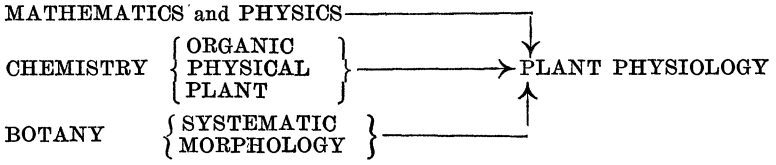
This lack of appreciation was recently called to our attention in a striking manner. An inquiry was made by a botanist about an astronomical publication on solar radiation. The astronomer replied that there was nothing in the article that could be appreciated or be of any value to a botanist. In contrast to this lack of appreciation for the necessity of cooperation we may quote a prominent scientist on the problem of photosynthesis:[9]

> . . . the chemical reactions constituting the photosynthetic processes are of a highly complex and intricate nature, sufficient investigation has been done to justify the conclusion that the problem is amendable to physico-chemical treatment. However no single academic division of science, such as botany, chemistry or physics is of itself sufficiently rich in concepts and methods to attack the problem adequately. . . . In view of the present academic divisions of the sciences and the variety of special training which is requisite for such undertaking, cooperative effort offers the only rational method of advance.

Again, we are told that an eminent chemist once said that the progress of our knowledge of photosynthesis has been retarded more than a hundred years by being in the hands of botanists. No statement was made as to the condition of our knowledge if it had been in the hands of chemists. It is not difficult to cite many examples in which valid criticism can be offered of chemical research on plant material because of lack of appreciation of the importance of plant structure and physiological processes.

We believe that the plant physiologist is largely a product of his training, and if his training does not prepare him to do research work which will develop his field of science, it is not, as a rule, satisfactorily acquired when the occasion demands. We also believe that the demand for plant physiologists will greatly increase when they are better prepared to handle the problems to be solved. As a step toward making it possible for those interested in research work in plant physiology to obtain the necessary fundamental training in the minimum amount of time, we suggest that a course in plant physiology be offered by the larger universities.

The following scheme may serve to show the relation of the fundamental sciences to plant physiology and suggest the necessary subjects.



It is understood, of course, that these subjects follow the usual prerequisites. A detailed outline of a course will depend upon conditions and individual interests.

It is quite probable that this course will not satisfy the requirements of any one department in most universities having a major and minor system. Thus it is necessary to have *departmental cooperation,* especially between botany, chemistry and physics. We believe that this *departmental cooperation* will greatly stimulate interest and facilitate *individual cooperation* which is necessary in the more technical and highly specialized branches of research in plant physiology.

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[9] Spoehr, H. A., *Jr. Ind. and Eng. Chem.* 14, p. 1145, 1922.

SCIENTIFIC EVENTS

THE BRITISH NATIONAL INSTITUTE OF POULTRY HUSBANDRY

THE selection of the Harper Adams Agricultural College as the site for the National Institute of Poultry Husbandry—the nucleus of the Ministry of Agriculture scheme for the development of the poultry industry—was influenced to a great extent by the value of the work already accomplished for poultry keeping at that institution.

The London *Times* reports that the equipment of the institute, which the Duke of York will formally open on November 3, is practically complete apart from the administrative building. For practical purposes the experimental station is already in operation, and during the present season important work has