# SCIENCE

VOL. LVII  JANUARY 5, 1923  No. 1462

*The American Association for the Advancement of Science:*

*Certain Allurements in Physics:* PROFESSOR G. W. STEWART ... 1

*The Origin and Structure of Plant Galls:* PROFESSOR MELVILLE T. COOK ... 6

*The Course of the Gulf Stream in 1919-21 as shown by Drift Bottles:* PROFESSOR JAMES W. MAVOR ... 14

*Scientific Events:*

*The Preparation of Staining Solutions; Symposium on Materials, of Chemical Equipment Construction; Ten-Year Program of the New York Agricultural Experiment Station; The Centenary of Pasteur's Birth* ... 15

*Scientific Notes and News* ... 17

*University and Educational Notes* ... 22

*Discussion and Correspondence:*

*The Indexing of Biological Literature:* PROFESSOR T. D. A. COCKERELL. *Specific Terms for the Proteolytic Activity of Anærobes:* DRS. E. C. L. MILLER and G. F. REDDISH. *The Standardization of Biological Stains:* DR. H. J. CONN ... 22

*Quotations:*

*The Royal Society; A Psychological Corporation* ... 25

*Special Articles:*

*The Mode of Reaction of Highly Insoluble or Undissociated Salts:* DR. BENJAMIN S. NEUHAUSEN. *The Musch Rain-correcting Mounting for Porous Porcelain Atmometers:* PROFESSOR G. E. NICHOLS ... 26

*The Indiana Academy of Sciences:* HARRY F. DIETZ ... 28

SCIENCE: A Weekly Journal devoted to the Advancement of Science, publishing the official notices and proceedings of the American Association for the Advancement of Science, edited by J. McKeen Cattell and published every Friday by

THE SCIENCE PRESS

100 Liberty St., Utica, N. Y.  Garrison, N. Y.

New York City: Grand Central Terminal

Annual Subscription, $6.00  Single Copies, 15 Cts.

Entered as second-class matter January 21, 1922, at the Post Office at Utica, N. Y., Under the Act of March 3, 1879.

## CERTAIN ALLUREMENTS IN PHYSICS[1]

THERE is no doubt as to the alluring nature of physics. We are led on as reasoning, imaginative dreamers who never attain full intellectual satisfaction but who are always sufficiently rewarded to be happy to participate either as workers or as spectators. The fascinating quality of physics is not our concern here, but in the atmosphere of the recognition of this drawing and compelling power, certain of our present problems will be briefly discussed.

It is doubtful if ever there has been a more inviting appeal to imaginative reason than can be found at present in atomic structure and radiation theories. The search in this field is, in fact, so exciting that we can easily forget the mysteries in our own hypotheses. The progress of the last decade has been rapid. Only thirteen years ago Professor Rutherford in his Winnipeg address set forth the claim that sufficient evidence had at that time been adduced to place the theory of the existence of atoms in the classification of accepted fact. To-day, with perhaps equal conservatism, several details as to the structure of the atom can also be regarded as accepted. The existence of the nucleus, with a diameter of about $10^{-12}$ cm. or less no one doubts, though our direct evidence is based upon but one type of experiment, namely, the impact of an $\alpha$ particle. The size of the charge of the nucleus, its sign and the fact that $\alpha$ particles and H particles exist in at least some of the nuclei are certainly just as true. But we would be willing to sacrifice a great deal to know more of the content of and arrangement in nuclei. We may be nearer the acceptance of the existence of $\alpha$ particles, protons and electrons as the units of structure

[1] Address of the vice president and chairman of Section B, physics, American Association for the Advancement of Science, Boston, December, 1922.

in all nuclei than some of us realize. Reasonable deductions from isotopic measurements may convince us as to this composition, but at the moment the experiments of Rutherford and Chadwick upon H particles give us the hope of a direct and hence a more valuable means of attack. The extension of the measurement of the masses of isotopes with the remarkable present accuracy developed by Aston and Dempster will undoubtedly lead to the recognition of classifications that will at least indicate, if not prove, nuclear composition, but the interpretation of the H-particle experiments demands a very much higher accuracy. Rutherford and Chadwick have produced H particles from the nuclei of six of nineteen light elements and in five of the six with an increase in total kinetic energy of from 6 to 42 per cent. of the kinetic energy of the colliding $\alpha$ particle. A consideration of the relativity change in mass of the H particle is important, although perhaps not yet profitable. For the kinetic energy of a 7 cm. $\alpha$ particle is $.009c^2$ per gram-atom, $c$ being the velocity of light, hence the change in mass produced by this energy is .009 grams per gram-atom, or in atomic weight units, .009 for each $\alpha$ particle. If at impact 42 per cent. of this energy is acquired by the nucleus and $\alpha$ particle as shown by experiment, there must be a total increase in mass of .42 x .009 or .004 or 0.4 per cent. of the mass of an H particle, or .01 and .03 per cent., respectively, of the masses of aluminum and boron, two of the elements concerned. At least this accuracy in atomic weight measurements must be obtained before a relativity consideration can even begin. The development of highly improved methods is of great importance.

In regard to the arrangement and activities of the extra-nuclear electrons, the status of atomic structure theory is rapidly improving. Three years ago at this session we had a discussion in which a suggested reconciliation of the so-called static and orbital theories was presented. At the present time one can say with a fair degree of confidence that reconciliation is neither probable nor desirable. The static theory appears superior as a picture to be used in the discussion of periodic physical and chemical properties of the elements, the magnetic properties and compound formations. The orbital theory appears to be a more powerful method of attack, partly because it is not hindered by a consideration of the mechanism of radiation and partly because it relies upon principles and mathematical methods instead of upon visualization. The attempt to mix the two would probably seriously decrease the future real benefits of both. The static atom is valuable not merely because the spacial relations can be visualized but also because, to the extent that it affords such an excellent partial explanation of phenomena and is successful in the predictions of properties of new compounds, it must have a measure of truth. But in some respects it is misleading. Conventionality must not be accepted as a reality. The use of the term "cell" leads to a perhaps unconscious satisfaction that does not bear analysis. Moreover, the position of an electron in a cell on the outermost shell seems to make molecular formation much easier than if the electron has any sort of orbital motion. But yet the converse may be nearer the truth. This is not an effort to criticize the static atom theory. It is merely a reminder of the danger of overenthusiasm concerning any explanation that depends upon visualization.

The present orbital theory of atomic structure, as enunciated by Bohr, is strikingly different both as to content and as to value. It is less of a picture and more of a theory. Stability is not neglected but emphasized. So detailed has become the development of the theory that perhaps a brief non-technical description is appropriate to this address. Until recently our orbital conception based upon the work of a number of contributors could be sketched in the following manner. The fundamental assumption was a generalization of Planck's quantum, which not only gave the frequency relation, but stipulated stationary states of an atom system. By orbits, circular or elliptical, with a central nucleus and a single electron radiating as it passed from one stationary state or energy level to another, the Balmer, Paschen and Lyman series of atomic hydrogen and the series of ionized helium were computed with high accuracy. By assuming elliptical orbits and a relativity change in mass of the electron, the fine structure of hydrogen approximately and of ionized helium more exactly, were obtained. Extending the theory and assuming internal X-ray energy levels, X-ray doublets were computed and found to agree with experiment. By assuming the presence of an unsymmetrical field external to the nucleus and inner electrons, the well known series formulæ of the alkali metals could be quickly derived. By the application of an electric field, not only the general phenomenon but also the details of the Stark effect were obtained. The Zeeman effect was explained as well as was formerly done by the classical theory. By the application of the "correspondence principle" the intensity and state of polarization of lines for large orbits and more approximately for small orbits were obtained. But in this remarkable theoretical work, producing quantitative agreements that were exceedingly impressive, no account was taken of the spacial distribution of orbits and no explanation was given of the variation of physical and chemical properties as shown by the periodic table. We had, then, two pictures of atomic structure, one with electrons in cells and shells, and one with electrons in coplanar orbits. But because a spacial distribution of electron orbits was demanded on several grounds, some progress was made in considering such a distribution by the polyhedral symmetry of electrons which in the coplanar model had the same orbit. Bohr's recent description in the Zeitschrift für Physik of 1922 seems to abandon a rigorous theoretical approach but, at the same time, to profit by the theoretical investigations of the foregoing idealized conditions. He adheres to the quantum theory and applies the correspondence principle as a substitute for our lack of knowledge of the inner connection which determines the possibility of radiation or a quantum change. He concludes that there is no modification in the former hydrogen atom model. The helium atom in the normal state has two approximately circular electron orbits, having an angle between their axes of 120°, with the planes turning slowly about the fixed axis. Preliminary computations promise the experimental value of the ionizing potential. These helium orbits remain a fixed substructure in all elements of higher atomic numbers. Bohr ascertains the structure of succeeding elements in the periodic table by obtaining an answer to the question, "How can the atom be built through successive seizure and binding of the single electrons in the field of force surrounding the nucleus?" He is led by this approach to a conclusion as to the nature of the orbits of the elements. Briefly, the orbits are approximately circular, elliptical and highly elliptical, resulting in an interpenetration of orbits. Electrons having relatively large energies will, on account of the greater ellipticity of their orbits pass closer to the nucleus than do other electrons possessing smaller energies and moving in orbits of less eccentricity. The visits to the interior by a group of electrons in noncoplanar elliptical orbits of a certain energy, do not occur simultaneously, for the electrons approach the nucleus alternately with equal time intervals. Because of the interpenetration of orbits there is an intimate coupling of the electron orbits of the different groups indicated by quantum numbers, and also an independence of the nature of the binding of the electrons of one and the same group. Bohr discusses the entire periodic table, showing how this structure may explain the chemical and physical periodic phenomena. He has abandoned rigorous treatment, merely because it is no longer possible. Another new result of Dr. Bohr's investigation is that at four different regions in the periodic table, the added electrons find more stable adjustments by becoming members of groups formed earlier in the building up process. The ferromagnetic metals are near the end of such an inner change or what might be termed the healing process of an internal wound of the atom.

In the above it is observed that our former relatively simple picture of an orbital atom has gone and we have, in an atom of high atomic weight, a maze of interpenetrating orbits too complicated to visualize. But we have a description of the atom in terms of quantum numbers and nuclear charges. While this remarkable conception looks very promising indeed, we must patiently await a very slowly accumulating rigorous treatment. The forthcoming publications of Dr. Bohr will be received with great interest. He is just publishing an article on X-rays in collaboration with Dr. Coster in which there is derived a very strong support for the main features of the new theory. He has been working out and will soon publish details in regard to the series spectra and will show that the new views throw much additional light in respect to the main feature and also the quantitative details.

The above description will indicate that an attempted reconciliation between the static and orbital theories would probably prove either unsuccessful or unprofitable. We ought to be willing to use either theory freely wherever of service. But it is almost inevitable that in the future, though we may adhere to pictures for elementary students, in the work of investigation we will get further and further from models and become more and more satisfied with principles which, although not containing ultimate explanations, nevertheless are apparently the nearest approach to the truth. Obviously the function of pictures is seriously limited, for our natural ability to gain by visualization does not increase materially from generation to generation, whereas our power of attack through mathematical investigations based upon principles does accumulate with the elapsing years. It is not surprising, therefore, that it is easy to have more faith in the greater fruitfulness of the orbital theory as compared with the static theory.

It is folly to prophesy seriously as to the direction of future progress in the theory of atomic structure. But there are certain evidences that are worthy of consideration. The quantum theory seemed a few years ago to be a curious as well as a remarkable element in Planck's theory of radiation, the oddity of the quantum reflecting merely the difficulties of the problem. To-day, we regard a quantum theory more seriously. Although not as consistent as the classical theory, its use in radiation is or should be just as orthodox. While formerly we were inclined to call attention to the formal character of the theory and the failure to explain any mechanism underlying it, to-day we realize that neither the classical nor the quantum theory gives us the mechanism. This mechanism, though fundamental, is a detail and the evidences is that we can make progress more rapidly by following a successful formal principle than by speculating about the nature of the mechanism itself. Our willingness to adopt as a working theory such a formal principle is not a fault but a virtue. Such a principle attacks, as it were, from without and its successes and failures are determined in that region. Hence we can not hope to judge or improve the method by speculations from within. Progress in atomic structure can certainly be anticipated by following either the quantum theory or perhaps a substitute not yet suggested. The accumulation of data along our present restricted lines of experimentation must of course be of permanent value. But until another formal principle is found that is more successful than the quantum theory or until a hitherto unsuspected region of observation is opened up, we can scarcely expect any material modification in our present views of atomic structure in so far as they are applicable to experimental test. But we have not arrived. The attack upon the problem has but begun. The allurement remains.

Having commented upon the most attractive problem in physics, I turn now by way of contrast to a field regarded by many as possessing but little interest. During the war many physicists remarked that acoustics was at last coming "into its own." Only in a limited sense was this true. Acoustics does not inquire as to the nature of its assumed continuum and hence is not a fundamental subject. It can never have the attractiveness of a fundamental field in which a small amount of progress may eventually lead to an extensive accumulation of valuable results. The chance of enlivenment in acoustics through new discovery is slight. But while the allurements are less the achievements for an individual may be more satisfactory because of their permanent value. This permanency rests upon two facts. In the first place the truth in the assumptions and approximations are clearly understood and any theoretical advance will not need to be thrown aside because of the incorrectness of the bases adopted. Moreover, the importance of acoustics will not wane. In this respect optics and acoustics are similar, for their interest to the race will last as long as will human vision and audition. Progress in acoustics undoubtedly is limited, but its importance will persist. I speak not as an advocate for greater attention to acoustics, neither would I urge in business one particular line over another. Men will go into big business enterprises, some to win and some to lose. Other men will be more conservative, taking less of a gambler's chance and consequently neither winning nor losing so great a stake. These differences in adjustment to allurements exist in the field of scientific research as well, and one must select that kind of investigation in which he can be most effective and happy. It is unfortunate, however, that physicists generally do not appreciate that acoustics is a difficult field, begging for the attention of masters of mathematical methods. The late Lord Rayleigh had a great mind, as is attested by his numerous contributions in almost all branches of physics. It has often been wondered why he remained strangely inactive toward such an attractive subject as the electron theory. The speaker, in the absence of information, is of the opinion that Lord Rayleigh's interest was controlled in part by the promised permanency of results. In acoustics he must have been attracted by the substantial correctness of the assumptions, for this insured a corresponding quality in the results obtainable by mathematical processes. It is much to be hoped that acoustics will receive an increasing share of the interest of our mathematicians.

Mathematical difficulties arise in even the most simple acoustical devices. For example, a solution has not been found for the "end correction" of a conical horn. Until recently there has been no theory which included a discussion of the natural vibrations in a conical horn which are not radial, but Dr. V. A. Hoersch has now found how to compute the frequencies of these other resonance frequencies, his solution providing for a horn of any angle, but with an infinite plane flange. An experimental test of this unpublished theoretical investigation has not been made. This same investigator has also shown the reason for the existence of an "optimum" horn angle. When a conical horn is used as a receiver there is an angle for which the amplification will be a maximum, assuming fundamental resonance. This angle is less when the vibration is an overtone than when it is the fundamental of the horn. But measurements demonstrating this effect require the escape of a small amount of energy at the vertex. It has now been proved by a fairly simple theoretical investigation that the cause of an optimum angle is this escape of energy. Were this loss zero, the amplification would continue to increase with decreasing angle until viscosity became a factor of importance. It is clear, then, that the adjustment of a conical horn as an amplifying receiver requires not only a knowledge of the frequencies involved but also of the nature of the apparatus at the vertex even though it may absorb but a small amount of energy. The suggestion should be made, in passing, that the incorrect conception of a conical horn as a collector of the incoming energy should soon be supplanted by a correct recognition of the horn as a resonator.

Acoustic problems are not without attractiveness *per se*. The acoustic wave filters just described in the December *Physical Review* are uncommonly interesting and partly because of the element of surprise. We are familiar with the nature and behavior of the medium and by daily experiences with sound transmission. Yet we are hardly prepared by experience to witness an unobstructed cylindrical tube an inch in diameter and a few inches long that refuses audible transmission to a large group of frequencies. Up to the present time, successful low-frequency-pass, high-frequency-pass and single-band and double-band filters have been constructed. Additional contributions to the theory by other workers, but not published, will probably add filters of a different type. Just what the future usefulness of the acoustic wave filters will be can not be estimated. But the permanency of our method of hearing with air as a medium necessitates the continued importance of methods of filtering which use this same medium. Moreover, as presented, the fundamentals of the theory apply to any medium whatsoever. This may prove of significance in several directions.

But it is not my purpose to discuss present problems of acoustics in any detail. Reference has been made merely to several items of progress in which the speaker's interest has been keen and in which the allurements have certainly been strong. It is appropriate, especially in this laboratory where we are in session to-day, that reference be made to one who here did much for the field of acoustics, Professor Wallace Clement Sabine. The desire is not to laud his contributions but to speak in simple terms of him as a person. There is very clear in memory his act of kindness to the speaker who was a young experimenter in another laboratory. It betrayed a genuine human interest that, wherever found, compels admiration. His mind was keen and full of suggestions to the students in this Jefferson Physical Laboratory. Although kind and generous, he was intensively a just man. Never aggressive in a bold sense, others sought him out. He was essentially modest, but he had confidence in his mental powers. He was fine in spirit, outwardly highly acceptable and, withal, a splendid type of gentleman. One can not forget him as a person.

G. W. Stewart

University of Iowa

## THE ORIGIN AND STRUCTURE OF PLANT GALLS[1]

The study of the histology of pathological tissues of plants has been very much neglected, especially in America. It is true that more or less extensive studies have been recorded and discussed in the papers on the various diseases of plants but nothing has been done towards bringing this data together into a comprehensive whole. In recent years this phase of botany has begun to attract attention, especially in the case of abnormal growths, which have been referred to under many names, such as cecidia, galls, cancers, hypertrophies and various terms which are more or less indefinite. It is the purpose of this paper to give a brief historical review of the phase of plant pathoanatomy which is involved in these abnormal structures. The fact that the author has made rather extensive studies of those plant galls which are the result of insect stimuli may be a sufficient excuse for attempting to discuss this very broad subject involving similar abnormal plant structures which are attributed to other organisms. Abnormal growths on plants are caused by insects, nematodes, fungi, slime molds, bacteria and chemical and mechanical irritations. Similar growths are also produced on animals; but, in general, it may be said that the causes are not nearly so well understood as in the case of plants. On the other hand the histology of abnormal animal growths has been the subject of much more extensive studies than that of those found on plants.

The plant galls which are caused by insects were among the first to attract attention and the early Greek literature contains many references to them. However, very little real progress was made until Malpighi published his "De Gallis" in 1686. This work was primarily descriptive but the author also advanced the theory that the excitation was due to a poison secreted by the mother insect. Although this idea was disproved long ago, there are some text-books which still retain this so-called "chemical theory" of more than two hundred years ago. The next great advance was about fifty years ago and was marked by Adler's "Ueber den Generations-wechsel der Eichen Gallwespen," a work dealing entirely with oak galls caused by insects. The works of Adler, Beyerinck and their contemporaries gave us very definite information concerning the life history of some of the causal insects and the structures of certain insect galls, and disproved the theory that the excitation was due to a fluid secreted by the mother insect.

The European literature is much more extensive than the American. In this country the major part of the work has been by entomologists but within recent years has attracted the attention of several botanists and papers have been published by Cosens, Rosen and Wells. Felt's "Key to Insect Galls" is the most complete and usable work in our American literature for the determination of these plant growths. He lists and describes more than 1,400 species, a number which is no doubt insignificant when compared with the number of undescribed species. In most cases each species of insect cecidium is confined to a single specific host plant and those that occur on more than one host are restricted to closely related species.

A few species of nematodes are well known as the causes of abnormal plant growths. They are widely distributed throughout the world,

[1] Address of the vice-president and chairman of Section G, Botany, American Association for the Advancement of Science, Boston, December, 1922.