earlier developmental stages in other animals. Further study will be made on this point.

CLAY B. FREUDENBERGER
COLORADO COLLEGE

THE NATIONAL ACADEMY OF SCIENCES

AT the annual meeting of the National Academy of Sciences, held in Washington on April 25, 26 and 27, the following papers were presented:

The nature of the insensible perspiration: FRANCIS G. BENEDICT and CORNELIA GOLAY BENEDICT, Nutrition Laboratory of the Carnegie Institution of Washington. We have made numerous experiments, chiefly with one subject, in which the insensible perspiration has been analyzed, and the effects of environmental temperature, of the removal of clothing, and of a blast of air from an electric fan have been readily determined. Thus, a typical experiment showed in the preliminary period a total insensible loss, both from the lungs and skin, of 21.76 grams per hour, when the subject was nude in an environmental temperature of 25° C. In the next period, when the nature of the loss was studied, it was found that 7.58 grams per hour were lost from the skin, 8.13 grams were lost as water from the lungs, 17.08 grams of carbon dioxide were eliminated, and 15.36 grams of oxygen were absorbed. In another experiment at a room temperature of 20° C. the total loss, when the fan was blowing over the nude body, was 19.55 grams per hour. In a period immediately following, with the fan still going, 8.45 grams were lost from the skin, 7.29 grams were lost as water from the lungs, 22.54 grams of carbon dioxide were eliminated, and 19.81 grams of oxygen were absorbed. Although the results are in large part for one special subject, with whom experiments without clothing could be made, at least a dozen other persons have been studied with ordinary clothing, and the general deduction can be made that the total insensible loss in weight of the average woman, resting quietly, will be about 20 or 30 grams per hour. That of the average man will be nearer 40 grams per hour. Of this about 45 per cent. is in water from the skin, about 45 per cent. is in water from the lungs, and 10 per cent. represents the difference between the intake of oxygen and the output of carbon dioxide. The effects of the removal of clothing, of wind movement, and of temperature below the point when visible perspiration occurs are astonishingly small, chiefly because the skin temperature is profoundly lowered by such measures. The total insensible loss is a reliable index of the total metabolism and is finding use in modern clinics.

The embryology of Equisetum debile Roxb.: DOUGLAS HOUGHTON CAMPBELL, Stanford University. The genus Equisetum includes about 25 species, the sole survivors of a very ancient group of plants. A knowledge of the embryo is therefore of great importance in determining their relationships to the other Pteridophytes. No comprehensive study of the embryo has been made since that of Sadebeck in 1878, although several contributions to the subject have been made since. A large number of gametophytes of *E. debile* was sent the writer from India. These contained great numbers of embryos in all stages of development, so that it was possible to secure an almost complete series showing the early history of the sporophyte. *E. debile* differs considerably in some of the details of the embryo from the species (*E. arvense, E. palustre*) studied by Sadebeck, and more nearly approaches *E. hiemale* and *E. variegatum*. The most important point brought out in these investigations is the origin of the buds from which the secondary shoots develop. These buds are of endogenous origin, and sometimes, at least, arise from the root, thus closely resembling a primitive form, Ophioglossum. This fact supports the view already expressed by the writer that there is a real, if somewhat remote, relationship between the Equisetineae and the most primitive ferns. Both from its size, and from the many sporophytes produced from it, the gametophyte of *Equisetum debile* is strongly reminiscent of certain liverworts, especially Anthoceros.

Some aspects of protoplasmic surfaces: W. J. V. OSTERHOUT.

The effect of tubercle bacilli and the chemical fractions obtained from analysis on the cells of the connective tissues in rabbits: FLORENCE R. SABIN and CHARLES A. DOAN.

The effect of small amounts of chemicals in increasing the life activities of plants: F. E. DENNY, Boyce Thompson Institute. Plants in a dormant or relatively inactive period may be stimulated into increased activity by chemical treatment. Thus, the processes of coloration, which take place in lemons and oranges during storage after removal from the tree, may be hastened by treatment with low concentrations of ethylene (C_2H_4). The time required for coloration is reduced to about one fourth the normal time by adding to the air surrounding the fruit 1 part ethylene to 10,000 parts of air. The life activities of the fruit as judged by the rate of respiration is doubled or even trebled by this treatment. Potato tubers when freshly harvested are dormant, and will not sprout if planted at once under favorable growing conditions, the rest period lasting from 1 to 4 months in different varieties of potatoes. This period of inactivity may be shortened by treating the tubers with various chemicals such as thiocyanates (SCN), thiourea (N_2H_4CS), and ethylene chlorhydrin (C_2H_4ClOH). The gain in time of sprouting is about 2 to 6 weeks, depending on the variety of potato and the stage of dormancy at the time the treatment is applied. Twigs of apple, grapes, lilac, etc., also have this dormant period in autumn, and the buds of these species can be forced into early growth by treatment with certain of these chemicals, the gain in time of budding or blooming ranging from 1 to 9 weeks. It is shown that these facts are related to the general problem of growth in plants, and in particular to the theory of the mechanism of growth control, and to the causes of correlations in the growth of plant buds. These results have

found application in practical agriculture in the case of certain plants, and the possibility of extending them to include other plants is discussed.

The measurement of the heat production of nerve: A. V. HILL, University of London. The nature of the impulse transmitted by nerve has been a subject of continual discussion and investigation by physiologists. The most obvious hypothesis that the wave transmitted by nerve is of a physical character, analogous to that of other physical waves, was supported by the fact that it had always been found impossible, even with the most refined methods, to detect any heat liberation in a nerve as the result of stimulation. Against this view, however, were other well-established experimental facts, particularly: (1) that without oxygen the nerve gradually loses its power of conducting; (2) that after the strength of an impulse has been reduced by passing through a narcotized region it rises again to its full value in a region of normal nerve beyond, and (3) that the velocity of transmission of the wave is largely affected by a change in temperature. Recent improvements in experimental methods have made it possible at last to measure the heat produced by nerve during stimulation, thus disposing finally of the purely physical hypothesis of the nervous impulse, especially since it has been found that, as in muscle, the heat can be divided up into several phases of which the most important is that of "recovery" following activity. The observations on the heat are in agreement with those of other observers (T. Lunberg, Parker, Fenn) who have reported an increase in the oxygen-consumption, or the CO_2-output of nerve, following stimulation. The chief instruments adopted were: (1) a thermopile containing three hundred constantan-silver couples in a space of 1.5 centimeters, with various devices to shield it from disturbances and errors, and holding about six nerves of small English or Dutch frogs, and (2) a pair of moving coil galvanometers, coupled by a thermal-relay, allowing readings to about 2×10^{-12} amp., with a deflection time of about four seconds. With these it was found (employing 10 seconds of stimulation) that a *single* nerve impulse causes an initial rise of temperature of about 10^{-7}° C., which is followed by a prolonged recovery phase in which about nine times as much heat is given out as in the initial phase. The heat per impulse is not constant but diminishes considerably as the frequency of stimulation is increased. This shows that after a wave of activity has passed along, the energy available for immediate use in a subsequent impulse has to be restored, and confirms the idea, based on other work, that a wave travelling in the immediate "wake" of another is of a diminished intensity.

Physical, chemical and biological effects of high frequency sound-waves: R. W. WOOD.

Additional evidence as to the intercellular formation of connective tissue: GEORGE A. BAITSELL (introduced by Ross G. Harrison).

Generalizations of Waring's problem on powers: L. E. DICKSON.

Relationships in the spectra of the elements of the first row of the periodic table: R. A. MILLIKAN and I. S. BOWEN, California Institute of Technology. Practically all of the strong ultraviolet lines that can be emitted by the atoms of the first row of the periodic table in all stages of ionization of the valence electrons have now been obtained and a general statement of the relationships between the frequencies of these lines has been formulated. These relationships are presented most simply and compactly in a new graph which depicts the generalized form of the Moseley law in the field of optics. Similarly, a table of the ionization potentials of the atoms of the first row in all stages of ionization. Furthermore, the predictions of the Russell-Heisenberg-Pauli-Hund theory as to the structure of spectra in general have been completely verified in the case of these light elements.

Polarization of light by reflection from rough rock surfaces, with special reference to the materials exposed at the moon's surface: F. E. WRIGHT, Geophysical Laboratory of the Carnegie Institution of Washington. In the study of the surface features of the moon it is desirable to ascertain, if possible, what kinds of materials are exposed there. Our best approach to this problem is through the aid of the sun's rays that serve as messengers from the moon to us. We view the moon by reflected sunlight and we know from measurements that the reflected sun's rays differ slightly from the direct sun's rays. These differences are produced on reflection at the moon's surface; from these effects, in turn, we can draw certain conclusions regarding the reflecting substances themselves. For this purpose we measure the amount of polarization in the light reflected by the moon at its different phases, and also ascertain to what extent rough surfaces of rocks and other materials polarize light on reflection. An extended series of measurements on different kinds of rocks, such as basalt, diabase, gabbro, dunite, serpentine, diorite, granite, obsidian, pumice, quartzite, shale, sandstone, limestone, marble, etc., has been made. The results show that only highly siliceous rocks, such as pumice, siliceous sinter, granite, quartzporphyry, also sulfur, and powders of transparent substances, but not basalts and other basic rocks low in silica, produce polarization effects similar to those observed in the rays reflected by the moon. The amount of polarized light in the rays reflected by the moon is slight at all angles of incidence and is practically nil at new and at full moon.

High dispersion stellar spectra and some results of a study of Cygni: WALTER S. ADAMS and ALFRED H. JOY, Mount Wilson Observatory. The use of the 100-inch telescope at Mount Wilson and a large stationary spectrograph has made it possible to photograph the spectra of stars on a scale larger than any employed regularly hitherto. These spectra are especially well adapted for the study of the identification and behavior of different classes of lines, accurate determinations of radial velocity and the displacements of lines of different elements. A special study of the spectrum of Cygni, a star of spectral type very similar to that of the important Cepheid variables, has resulted in the identification of many lines

previously unknown. Most of these belong to the spectrum of the ionized elements. The spectra of the rare earths, especially cerium, neodymium and samarium, are prominent and the entire spectrum is very similar to a reversed solar flash spectrum as seen at a total eclipse. Measurements of the ionized cerium lines indicate that the low-level gases of this element of high atomic weight are rising in the stellar atmosphere at a velocity of about 1.4 km./sec. as referred to the normal iron vapor. The presence of convection currents in the atmosphere of the star is also confirmed by the displacements toward longer wave-lengths of the lines due to ionized elements with reference to the lines of the normal atom.

The relationship of spectral type to period among variable stars: WALTER A. ADAMS and ALFRED H. JOY, Mount Wilson Observatory. A knowledge of the relationship between length of period and spectral type among variable stars, especially those of the Cepheid type, is most desirable in view of their importance in the study of stellar distances. While it has been known in a general way that the spectral type is more advanced the longer the period, no accurate correlation has been established because of the difficulty of the accurate spectral classification of these faint stars. A study of over 60 of these variables with the 100-inch telescope at Mount Wilson provides the material for such an investigation. It is found that a large majority of the Cepheids, including all of the brightest and best known stars, show very nearly a linear relationship between spectral type and the logarithm of the period. The few exceptions all have spectral types which are less advanced than would be expected from their periods, and may perhaps form a separate group allied to the irregular variables. The comparison of the results for the Cepheids with those for the short-period cluster-type stars and the long-period red variables gives the rather surprising results that these two classes fall on the average close to the curve derived from the Cepheids. The cluster-type variables, however, show considerable range in spectral type with but little range in period, although their mean values are in good agreement with those of the Cepheids. The conclusion seems to be justified that the physical cause of the variation in light of these different classes of variable stars is similar and probably is to be ascribed to a periodic variation in size.

The variation of the absorption of X-rays with wave-length: F. K. RICHTMYER, Cornell University. The systematic way in which the absorption of X-rays by various media varies with the wave-length of the rays and with the atomic number of the absorber has stimulated attempts, both theoretical and experimental, to determine the exact law involved. Several formulae have been proposed on theoretical grounds, which predict that, after eliminating scattering, the absorption varies as the cube of the wave-length (λ). This proposed law is approximately verified experimentally. But, as pointed out by the author (*Phys. Rev.*, July, 1921), and as has been found by other investigators, there are slight deviations from the cubelaw over wide spectral ranges. Recently Oppenheimer (*Zeit. für Physik.*, Feb. 14, 1927), on the basis of the new Schrodinger theory, deduces that the exponent of λ should be $3+\beta$, where β is a small fraction which varies from $+0.3$ to -0.3. It seemed desirable to obtain data, as precise as might be possible, to check Oppenheimer's conclusions. By methods previously described, and by use of a high-power water-cooled X-ray tube, the author has investigated the absorption coefficient of Sn, on the short wave-length side of the K absorption limit, using a spectrometer with very narrow slits. Within the limits of experimental error (not greater than 0.2 per cent.) a curve plotted between the absorption coefficient and the cube of the wave-length is rigorously a straight line from the absorption limit ($\lambda = 0.42$A) down to about 0.27A: *i.e.*, in this range β is zero. Below this wave-length observed values of the absorption coefficient are consistently lower than would be predicted by the straight line: *i.e.*, β may have a small positive value in this region. The exact determination of β presents serious experimental difficulties, partly because of the unknown correction for scattering, partly because of the limitations of precision inherent in measurements of this kind. The author takes pleasure in acknowledging assistance from Mr. L. S. Taylor in making the observations. The investigation was supported in part by a grant from the Heckscher Research Council of Cornell University.

Theory of normal cathode fall: K. T. COMPTON and P. M. MORSE, Princeton University. The problem has been attacked from the standpoint that the field in the cathode fall space is so distributed as to give maximum ionization, subject to the restrictions imposed by Poisson's equation. This principle, together with the experimental values of the cathode fall V_n and of the average number of ionizing collisions α made by an electron in unit path, enables us to calculate the thickness of the cathode dark space d_n and the current density j_n for any gas at any pressure and with any cathode material. These calculated values are in rather good agreement with experimental observations. The factors which determine V_n are discussed, but independent evidence on this point is not available. V_n is the least potential drop which (given its most favorable distribution) can produce enough ionization to insure a continued supply of electrons from the cathode under positive ion bombardment. The number of positive ions required to liberate one electron under these most favorable conditions is found to vary from 21.5 to 109 for different gases and a Pt cathode. The most favorable potential distribution gives results which are quite consistent with Poisson's equation. Provided the current j does not exceed A_{j_n}, where A is the cathode area, it is shown that the cathode drop must remain constantly V_n independent of the current. If $j > A_{j_n}$, however, it is shown that the most favorable potential distribution is no longer consistent with Poisson's equation. If in this case we take, as the true potential distribution, that one which is most favorable *subject to the limits imposed by Poisson's equation*, we get approximately the relations which are known to be true of the *abnormal*

cathode fall. This case has not yet been quantitatively worked out, however. In general the present theory appears to be much more satisfactory than any previous theory of the cathode fall as regards the number of phenomena explained, the quantitative agreement of theory with observation, and the general reasonableness of the mechanism of the discharge.

Special distribution of the photo-electrons ejected by X-rays: E. C. WATSON, California Institute of Technology. The experiments of Wilson, Auger, Bothe, Bubb, Loughridge, and Kirchner by the C. T. R. Wilson expansion chamber method have shown that the most probable direction of the photo-electron tracks in a gas traversed by X-rays is nearly the direction of the electric vector of the incident wave, but with an appreciable forward component. There is, however, a very considerable variation in the direction of the tracks. Magnetic spectra of the electrons ejected from very thin metallic films at various angles show similar effects. Theories making use of orbital velocities inside the atom to account for this apparent emission from the atom over a wide range of angles instead of in one definite direction have been proposed by Bothe, Bubb and Auger and Perrin. It can be shown, however, that simple nuclear scattering must be present in all the experiments in sufficient amount to account for the distribution in direction, and the Rutherford theory of nuclear scattering leads to a distribution function which fits the facts much better than any of the more elaborate theories. The simplest conclusion then is that all the electrons ejected from an atom by X-rays start out in the same direction. This leads to a great simplification in our conception of the nature of the force exerted on an electron by a field of radiation.

Preliminary revision of Rowland's tables of solar spectrum wave lengths: CHARLES E. ST. JOHN.

Application of the law of similitude to hydraulic laboratory research: GEORGE DETHIERRY, Technische Hochschule, Berlin-Charlottenburg, Germany. Application to hydraulic laboratories is based on Newton's theorem 26, Section 7, like bodies in like situations are considered to be moved among themselves with like motions and in proportional times. Relations resulting from geometrical analogy are given for linear superficials, volumes, velocities, time intervals, water discharge, forces, energy, momentums, friction head. Difficulties in application of laboratory investigation to river problems. Dr. Krey's formula for evaluating quantity of débris.

Report on the ether-drift experiments at Cleveland in 1927: DAYTON C. MILLER, Case School of Applied Science. The ether-drift interferometer which was used at Mount Wilson in California in the experiments of 1921–1926 has been mounted on the campus at Case School of Applied Science in Cleveland. Only minor changes, suggested by experience, have been made in the apparatus. Special precautions have been taken to obviate troubles caused by vibration from city traffic. A series of observations which will extend throughout the year, comparable with those made at Mount Wilson, is now in progress. The results for the first epoch of the series indicates an effect of the same order of magnitude as was obtained at Mount Wilson and consistent with the conclusions previously announced.

Periodicity in solar radiation: C. G. ABBOT, Smithsonian Institution. The author submitted monthly mean values of the solar constant of radiation for the years 1918 to 1926, in which certain systematic errors discovered by statistical methods have been eliminated. In these values a variation associated with the sun-spot cycle of 11 years is plainly visible. Higher solar radiation values attend increased sun-spot activity. A periodicity of 25 2/3 months having been noted, the values for 77 consecutive months, ending October, 1926, were submitted to Professor Dayton C. Miller for treatment by means of his harmonic analyzing machine. The result was exhibited graphically. The sun-spot period of 11 years could not be clearly shown by the machine (because it was operating on only 6½ years) and was represented imperfectly by the first and second components. The third component, 77/3 months, was very strong, and the fifth, 77/5 months, and seventh, 77/7 months, fairly strong. Also the overtones 77/6, 77/9, 77/12, 77/10, 77/14, were moderately conspicuous. These periodicities substantially make up the whole solar variation shown in the monthly mean values since May, 1920, except that due to the sun-spot cycle. It will be noted that the period 77/5 is substantially that found in world-precipitation by Professor Dinsmore Alter, and that the period 77/7 is that found by Clayton and Abbot several years ago. The resolution of hitherto apparently irregular solar variation into regular periodicities is interesting, and if confirmed by future observations may lead to forecasting methods of value.

A redetermination of the Newtonian constant of gravitation: PAUL R. HEYL, United States Bureau of Standards. The present accepted value of the Newtonian constant of gravitation rests upon the independent work of Boys and Braun thirty years ago. As discussed by Poynting (Article "Gravitation," Encyclopedia Britannica) the accepted value of this constant has been taken as 6.66×10^{-8}, with an uncertainty of one unit in the third significant figure. About three years ago the Bureau of Standards undertook a redetermination of this constant with the object of obtaining another decimal place. The method was that of a torsion pendulum in a vacuum as used by Braun, observing the difference in the time of swing of the pendulum with the large attracting masses in the near and in the far positions. The two times of swing differed by five and one half minutes, the corresponding difference obtained by Braun being about forty-six seconds. The results so far obtained confirm the present accepted value and add the desired figure.

Differential invariants of irregular elements: EDWARD KASNER.

(*To be continued*)