talked about good will and cooperation, yet these qualities grew and flourished under his leadership. Most important of all was his faith in the value of fundamental research. When he asked me to join the laboratory I hesitated, telling him that I had never done anything practical in my life and mistrusted my ability to do so. "Don't worry about the practical part," he said, "that is my job. You go ahead and work on whatever you want to, and leave the rest to me." He lived up to his word. He himself tells the story of how he had to defend Langmuir, who had been working four years with no visible results. "Leave Langmuir alone," he said, "he is getting valuable data." The next year Langmuir brought out the gas-filled lamp, the following year the law of space-charge and the radio tube.

The laboratory that has grown up under his leadership is still small, scarcely 300 men. Its influence for public welfare is not so much *their* contributions to science and industry, as *his* contribution, as a pioneer in industrial research, in demonstrating what was by no means obvious, that pure research can be successfully carried on in an industrial laboratory, with profit and untold benefit to mankind.

For this eminence in the application of science to public welfare I commend to you Dr. Willis Rodney Whitney, pioneer of industrial research.

A. W. HULL

RESPONSE BY THE MEDALIST

I HIGHLY appreciate the honor you bestow in presenting to me this Marcellus Hartley Public Welfare Medal.

I am encouraged first to express a personal thought. I always lacked somewhat general civic virtue. I never wanted to be a mayor or a major. I usually quieted my critical conscience so as to concentrate selfishly on my attractive industrial job. Therefore, I greatly appreciate those plain words, "public service." Every one at heart wants to be of public service and all industries must hope to be. But nothing nicer could happen to an employee of an industry than such a reward from such a source.

Actually, however, I have been only a part of a machine or assembly line to which the reward more properly belongs. However, as representing a living active group of research men, I gratefully accept this token.

But I want to extend the explanations much further, back to one who did so much to encourage the use of new scientific truth in public service. While Bloody Queen Mary and Queen Elizabeth were burning at the stake countless persistent leaders of good and pure thought (Mary, the Protestants, and Elizabeth, the Catholics), Francis Bacon was devoting a long and useful life to advancing clearer conceptions of truth. It occurred to him that to learn with certainty how many angels could stand on the point of a pin, careful experiments and observations were necessary. Mary, Elizabeth and Bacon were each righteously and terribly in earnest, but their techniques greatly differed. Bacon advocated experiment, for there had accumulated an infinite ignorance about the truly infinite creation. He was so logical, so sincerely inquisitive and so persistent that societies for research and academies of science quite displaced the old Inquisitions. Bacon made it very plain that perpetual improvement in public welfare was only obtainable through honest, industrious interrogation of nature. We call that research.

In our particular research-group our duty is to help counteract the effects of obsolescence of electrical products and prevent interruption of employment of large groups by actively aiming at new electrical unknowns.

In such work we also found, somewhat as a by-product, that our research men could contribute to growing science by publishing their results. They have now published about one thousand scientific articles. These, I like to feel, are contributing thus to general knowledge and public welfare.

W. R. WHITNEY

ABSTRACTS OF PAPERS

Distribution of galaxies in the anti-center region: HARLOW SHAPLEY.

Solar corona photography: IRVINE C. GARDNER (introduced by W. W. Coblentz). The lenses of extremely long focal length (60 to 100 feet) and small relative aperture (1/80 to 1/200) that have been commonly employed for corona photography have two fundamental disadvantages; the image is larger than is necessary in order to insure that all resolved detail shall be recorded by the photographic emulsion; and the lens works too slowly to permit the outer portions of the corona to be photographed during an eclipse of short duration. A lens for eclipse photography has been specially designed and constructed at the National Bureau of Standards from optical glass made at the bureau's own glass plant. The lens is composed of four components, widely separated, has a clear aperture of nine inches and is corrected for all the third order aberrations over a large field, a feature impossible with the two-component (or three-component apochromat) telescope objective commonly used for eclipse photography. The equivalent focal length is approximately 19 feet and, as a by-product of the design, the lens has telephoto properties so that the overall length of the camera is only 14 feet. The camera is designed to permit focusing in the laboratory and a precise reproduction of the laboratory adjustment without further focusing at the eclipse station. The mount is designed to give extreme portability and to enable the camera to be rapidly erected by a small group of men. Consequently the use of the instrument does not require the occupation of the

eclipse site many weeks in advance of the eclipse, as has been the case with the larger corona cameras. This camera has been used at the eclipse of 1936 in Asiatic Russia under the sponsorship of the National Bureau of Standards and the National Geographic Society and at the eclipse of 1937 at Canton Island under the sponsorship of the National Bureau of Standards and the National Geographic Society-United States Navy Expedition. Satisfactory corona photographs were obtained at both eclipses in black and white and by color processes. These will be shown by projection.

Photometric measurements at the total eclipse of June 8, 1937: F. K. RICHTMYER. By means of several photoelectric cell photometers of different sensitivity, measures were made of the total light from the solar corona and this light was compared in intensity with the light of the full moon at the same altitude two weeks previously. Additional measurements were made on the "daylight" illumination during totality; that is to say, the illumination produced by corona plus full sky. The total light from the corona was found to be 53 per cent. of the light of the full moon at the same altitude, in substantial agreement with most of recent measurements. The "daylight" illumination was some ten times that produced by the corona alone, indicating that the general illumination during an eclipse is due to the infiltration of sunlight from outside the shadow. This is in entire agreement with the observation that the general illumination increased rapidly as totality progresses and just at the end of totality was some ten times its value at the beginning of totality.

Propagation of wave-packets in a stratified doubly-refracting ionosphere: H. G. BOOKER (introduced by F. E. Wright). The magneto-ionic theory in the form now in use is only suitable for investigating vertical propagation in the ionosphere. The theory is generalized so as to be capable of describing oblique propagation of a magneto-ionic component through the ionosphere without using a refractive index which depends in a complicated way upon an unknown angle of refraction. The fundamental formula of the oblique-incidence magneto-ionic theory is an algebraic quartic equation for a quantity q which depends upon the prescribed angle of incidence and which at vertical incidence becomes identical with the well-known refractive index. The four roots of the quartic equation for q correspond to the upgoing ordinary wave, the upgoing extraordinary wave, the downcoming ordinary wave and the downcoming extraordinary wave. The level in the ionosphere where the individual wave-crests are moving horizontally across a characteristically polarized wave-packet is given by the condition $q=0$, which is equivalent to putting the angle of refraction equal to $\pi/2$ in Snell's law. But the level of reflection of the magneto-ionic component is the level where the wave-packet *as a whole* is traveling horizontally, and is given by the condition that the root of the quartic equation for q corresponding to the upgoing magneto-ionic component should be equal to a root corresponding to a downcoming magneto-ionic component. The critical electron-density required for reflection of a magneto-ionic component can easily be as much as 25 per cent. in excess of the erroneous value which would be calculated by putting the angle of refraction equal to $\pi/2$ in Snell's law.

Diffraction gratings for astrophysical research: R. W. WOOD. Large plane gratings on aluminized pyrex blanks have been ruled for the Mount Wilson spectrograph of the 100-inch telescope, and for certain spectrographs of new design in process of construction at the Harvard Observatory. One of these throws 85 per cent. of yellow light into the first order spectrum (in comparison to the reflection from an unruled aluminum mirror). Complete measurements have been made for all wave-lengths, all orders of spectra, at all angles of incidence, with a photronic cell and wall galvanometer in the case of an 8-inch grating (15,000 lines to the inch) which concentrates over 75 per cent. of the light of the visible spectrum in the second order spectrum. This grating was ruled for the 100-inch telescope.

Preliminary report on a radiometric method of measuring ultra-violet solar intensities in the stratosphere: W. W. COBLENTZ and R. STAIR. With the aid of a grant from the Joseph Henry Fund and in cooperation with the radio section of the Bureau of Standards, during the past summer tests were made of a new radiometric method of measuring the spectral quality and total intensity of ultra-violet solar radiation at various altitudes above the earth's surface. The radiometric apparatus consists of a photoelectric cell and filter radiometer, combined with an audio-frequency generator and radio transmitter, transported aloft by means of unmanned balloons. The response of the photoelectric cell to ultra-violet radiation modulates the radio-frequency wave. The height of the balloons is indicated by a radio barograph. The radio signals giving the altitude of the apparatus and the ultra-violet intensities are received and recorded graphically at a ground station. Although altitudes up to 24 km were attained, owing to electrical interference and other difficulties strictly quantitative data were obtained only to a height of about 19 km. Below 14 km the ultra-violet transmissions of the filters remained fairly constant, indicating but little ozone below this elevation. Between 14 and 19 km the filters show a continuous decrease in transmission (a selective increase in intensity of ultra-violet of the shortest wave-lengths, imperceptible at sea-level) with increase in elevation indicating that at a height of 19 km the apparatus had passed through an appreciable portion of the ozone layer, variously estimated at 15 to 30 per cent. of the superposed ozone. The observation of practically no ozone below the 14 km level and a penetration of 15 per cent. of the layer, at a height of 19 km is in good agreement with previous explorations (the *Explorer* in 1934) taking into consideration the latitude of the observing station and the time of the year. From the results obtained the method appears highly promising for securing information on ultra-violet intensities and ozone distribution in the stratosphere. The work is therefore being undertaken anew, with improved apparatus.

The extension of measurements on sea-level cosmic-ray intensities to the North Magnetic Pole: R. A. MILLIKAN and H. VICTOR NEHER. Through the kindness of Dr. H. Carmichael, we sent a Neher recording electroscope on the Wordie Arctic Expedition of the summer of 1937. Within the limits of the observed daily fluctuations, never more than 2 per cent., we find no variation between magnetic latitudes 64° and 90°. Combining this with 1931 Millikan expedition from Pasadena to Churchill (mag. lat. 60° 30′), we conclude that within the same limits there is no latitude variation between Pasadena (mag. lat. 41°) and the North Magnetic Pole.

New light on the nature and origin of the incoming cosmic rays: I. S. BOWEN, R. A. MILLIKAN and H. VICTOR NEHER. As a result of measurements made in four different latitudes with Neher recording electroscopes sent in balloon flights which reached a minimum pressure of but 9.9 mm of mercury (practically to the top of the atmosphere) we have found (1) that the curve of energy distribution of the incoming cosmic-ray electrons has a maximum at about 6 billion electron-volts; (2) that this curve falls to less than one third its maximum value both at an energy of 1 billion e-volts and at 20 billion e-volts; (3) that this type of banded structure renders it unlikely that the cosmic rays originate in portions of the universe in which matter exists in appreciable densities; and (4) that the observed energies of the cosmic rays are about those to be expected if the abundant elements have the capacity to transform their mass-energy completely into cosmic ray-energy.

The binding energies of the heavy nuclei: A. J. DEMPSTER. The exact comparisons of the masses of the various atoms show that they diverge by different amounts from integral values when referred to the lightest oxygen isotope at mass 16. This divergence divided by the nearest integer is called the packing fraction, and is connected with the binding energy of the nuclei of the atoms. The packing fractions for forty nuclei have been compared and a curve drawn to show how the binding energy varies for the different elements. The curve suggests a reason for the abrupt cessation of radioactivity with the element lead. The energy emitted in radioactive disintegration has an equivalent mass. The atomic weights of several elements as calculated from the isotopic structure agree better with the chemical determinations when this packing fraction curve is used.

An experimental study of the rate of a moving atomic clock: HERBERT E. IVES. According to the theory of the relation between matter and the stagnant luminiferous ether, as developed by Larmor and Lorentz, a moving clock should assume a slower rate, proportional to the square of the ratio of its velocity to the velocity of light. It was pointed out by Einstein in 1907 that the newly discovered Doppler effect in canal rays offered a means for making a test of this prediction. This experimental test, the crucial nature of which has been emphasized repeatedly in the last thirty years (under the designation of the "Transverse Doppler Effect") has not heretofore been performed. It has been commonly considered as beyond experimental practicability, chiefly on the ground that the moving canal rays are not homogeneous in velocity, the "displaced" line is too diffuse for sufficiently exact measurement. This objection has recently been removed, due to the development, by Dempster, of a design of canal ray tube which gives displaced lines of a sharpness comparable with the undisplaced. In this form of tube the positive ions produced behind the electrode are accelerated between two slightly separated pierced plates between which a high potential difference exists. The present investigation is an experimental test of the Larmor-Lorentz prediction, using canal ray tubes of the Dempster type. The hydrogen line 4861 A.U. has been used, observations being made by means of a plane grating of metal on glass of 15,000 lines to the inch, made by Professor R. W. Wood, which, in conjunction with two 5-inch diameter, 5-foot focus telescope objectives formed a sufficiently powerful spectrograph for the purpose. By means of a small concave mirror mounted on the pierced electrodes, end-on observation gave, on one plate, the displaced lines due to motion toward and away from the spectrograph slit. The apparatus was arranged to turn in any desired direction in the horizontal plane. Observations were made over a range of voltages from 7,000 to 19,000, using the displaced H_2 and H_3 lines. At the higher voltage, for H_2 the directly viewed and reflected displaced lines should, according to the theory, have their common center of gravity shifted, with respect to the undisplaced line, by approximately 0.05 A.U. The experiment shows the predicted shifts, which are independent of the orientation of the apparatus, and agree, within the errors of measurement, with the values indicated by the theory. On the assumption of a stagnant ether, this experiment, taken in conjunction with the Kennedy-Thorndike experiment, establishes the physical reality of both the Larmor-Lorentz variation of clock rate, and the Fitzgerald contraction. It is distinguished from the Michelson-Morley and other previous optical experiments by the fact that it yields a positive instead of a null effect.

Intensities of electronic transitions in molecular spectra: ROBERT S. MULLIKEN. Quantum-mechanical calculations on electronic transitions in diatomic molecules yield a useful classification of such transitions in respect to intensities. *Parallel-type transitions* ($\Delta\Lambda = 0$) in which an unexcited molecule goes to an excited state whose wave function is *strongly* or largely *ionic* in character should have very high intensity (examples, ultraviolet band-system of I_2 near λ 2000, Schumann-Runge system of O_2, Lyman system of H_2). The same prediction of high intensity follows, using either the atomic-orbital or the molecular-orbital method of approximation; the united-atom-orbital approximation, so far as it is applicable, also makes similar predictions. In terms of molecular orbitals, parallel-type transitions of the kind just discussed always involve the passage of an electron from a bonding to the corresponding antibonding orbital, and it may be predicted that such a passage (or its converse) should in general give very strong absorption (or emission). On the other hand, *perpendicular-type*

transitions ($\Delta\Lambda = \pm 1$) are less likely to have high intensity and can have very low intensity, especially in loosely bound molecules having only p valence electrons, of which the halogen molecules are good examples. Application to the visible halogen spectra of the foregoing results on parallel-type and perpendicular-type transitions completes a satisfactory explanation of these rather anomalous spectra. Under suitable circumstances, namely, when an electron in an s or in an s-p hybrid orbital is involved, perpendicular-type transitions may be expected to have moderate or high intensity. The foregoing results and their generalization to electronic spectra of polyatomic molecules should have considerable value for the systematic understanding of such spectra. The preceding discussion does not apply to the Rydberg series regions of molecular spectra, but only to the longer wave-length or sub-Rydberg spectra which lie in the visible and the more or less near ultra-violet. It should, however, be noticed that a sharp distinction can not always be drawn between sub-Rydberg and Rydberg regions; frequently a strong transition in the borderland of the two regions can be assigned more or less justifiably to either one or to both of them (example, Lyman band-system of H_2). In the true Rydberg series spectra, intensity relations similar on the whole to those in atomic spectra are expected, but interesting special features are also predicted.

A class of orthogonal functions on plane curves: DUNHAM JACKSON. The notion of a system of polynomials in one variable orthogonal with respect to an arbitrary weight function is modified and in a sense generalized by substitution of trigonometric sums for the polynomials. Another generalization results from the consideration of polynomials in two variables orthogonal with respect to integration along an algebraic curve in the plane of the variables. These two ideas are combined in the present paper to define a still broader class of orthogonal functions, in the study of which attention is given both to formal properties and to questions of convergence of the resulting developments in series.

The geometry of motions and whirls: EDWARD KASNER. Translations and rotations in a plane generate the three-parameter group of rigid motions M_3. If we operate on the opulence of lineal elements by slides and turns we generate an isomorphic group W_3, the group of whirls. This may be termed the *skating group*—think of sliding and pivoting on the ice. Together M_3 and W_3 generate a new six-parameter group G_6. We obtain this group by skating on a moving floor. This fundamental group is employed as the basis of a new type of geometry. In particular the invariants of differential elements, turbines, flat fields and quadric fields (simple differential equations) are determined. Quadratic fields are classified into seven types.

Symbolic dynamics: MARSTON MORSE and ARNOLD HEDLUND. The classical theory of dynamical systems as developed by Poincaré, Birkhoff, Hadamard and more recently by the authors, make use of the methods of differential geometry and in the last years of a powerful symbolic analysis. The symbols used are unending sequences whose terms are taken from a finite set of generating symbols. These symbols represent the typological or group theoretic operations which form the bone of the dynamics. In the past the symbolic aspects of dynamics and the differential aspects have been interwoven so as to be highly dependent. The authors find it possible to develop a symbolic dynamics independent of the theory of differential equations. The basic questions of recurrence and transitivity must be met on this basis in the first instance. Following this symbolic analysis suitable hypotheses concerning the degree of instability of the dynamical system enable one to carry over the symbolic theorems to ordinary dynamics. Having resolved dynamics into these two aspects various new theorems are obtained both on the symbolic side and on the side of the theory of space forms bearing transitive geodesics.

Pentagons formed by seven planes in projective space: H. S. WHITE. When seven planes lie in the space of projective geometry, no more than three meeting in any point, they divide that space into forty-two convex polyhedra, or not more than nine species, with convex polygons for faces. The problem arises, to describe that system of polyhedra, in all its possible varieties, numerically and tactically. That problem has unique solutions in the case of four, five or six planes. For seven, many solutions being possible, it is proposed to attack first a simplified problem, neglecting polyhedra whose faces do not include pentagons or hexagons. The investigation has been conducted experimentally with a minimum of deductive reasoning, and the results are presented in ten merely schematic diagrams. But these are believed to indicate sufficiently convenient lines for abstract discussion.

New or modified chlorophylls resulting from a recessive pale mutation in Datura: O. L. INMAN and A. F. BLAKESLEE (introduced by C. F. Kettering). Pale-7 is a recessive character bringing about a reduction in green color in leaves of Datura stramonium. The gene is a recessive and was induced by x-rays treatment of seeds. It has been located in the 1-half of the 1.2 chromosome. When heterozygous Pale-7 has no observable effect upon either the amount of chlorophyll or upon the spectrum. In the homozygous condition, however, an acetone leaf extract transferred to ether gives an absorption spectrum which is definitely different from the normal chlorophyll a + b mixture spectrum in the number and relative positions of the absorption bands. This is true for the crude extract and for an extract partially purified by chromatographic fractionation on an inulin column and then on a sugar column. When acid is added to the ether solution, the formation of pheophytin by the substitution of two hydrogen atoms for the magnesium atom in the chlorophyll molecule takes place. The pheophytins are also different from the normal pheophytins in their absorption spectra. Up to now insufficient material has been available to complete the purification and analysis of the product. Until this is done, the spectra shift and other possible differences can not be adequately explained. So far as the authors are

aware this is the first instance where different chlorophylls have been found in green plants.

Thiamin and growth of Pythium Butleri: WILLIAM J. ROBBINS and FREDERICK KAVANAGH (introduced by B. O. Dodge). Previous work has shown that some fungi form thiamin from the elementary materials of the medium, while others are unable to do so. Of those which form thiamin some are unaffected by its addition to the medium, while the growth of others is more or less inhibited. Amongst those organisms which require for growth the addition of thiamin to the medium there are some which are incapable of synthesizing either of the vitamin intermediates; some which form one or the other; some which lack the ability to form thiamin even if both intermediates are supplied. *Pythium Butleri* appears to differ from all the types enumerated above. It resembles some of them in its ability to grow in a suitable synthetic medium which lacks any organic growth supplement. It differs in responding favorably to the addition of thiamin to the medium. Apparently *P. Butleri* synthesizes thiamin from the elementary materials in the medium but in amounts inadequate for maximum growth. Furthermore, the composition of the medium, particularly its concentration, injuriously affects the growth of this organism; the inhibition of growth in the more concentrated solutions appears to be related to a reduction in the amount of thiamin produced by the organism. Our results suggest further that *P. Butleri* forms more of the vitamin thiazole than of the pyrimidine intermediate, and in a liquid medium containing mineral salts and sugar the pyrimidine synthesized by the organism is the factor limiting its growth. We have found that inorganic salts are a satisfactory source of nitrogen for this fungus. These observations confirm the importance of thiamin as a growth substance for plants; they show further that the amount formed may be a limiting factor in the growth of an organism and that cultural conditions which inhibit growth may be effective because of their influence on thiamin formation.

The distribution of electric potential on the external surface of single cells: E. J. LUND (introduced by H. S. Jennings). When the distribution of electric potentials between microscopic areas on the external surface of living Pithophora and Nitella cells were carefully measured and mapped out by a new method, it was found that different microscopic areas or spots on the external surface have inherent electric potentials of characteristic magnitudes. Between such spots of different potential there flows continuously local electric currents. With such electrode connections it seems evident that the internal (sap) and external solutions (tap water) are symmetrical and that the P. D. and energy source could only be located "in" the protoplasmic film separating the two solutions. The demonstration that there exists a regular distribution of increasing electric potential along the external longitudinal surface of the cell in Pithophora shows that this structurally polar cell possesses an inherent ("protoplasmic") electric polarity which is not due merely and only to differences in concentration of ions in the cell sap or external medium or both. The characteristics of the electric polarity in these cells are similar in all general respects to those in the onion root, oat coleoptile, Chara, Douglas fir, hydroids, Elodea leaf, etc., which we have previously studied in detail. The validity of the principle of algebraic summation of electric polarities of cells in a polar tissue (root tip) has been demonstrated for the linear cell aggregate in Pithophora.

The public and the cancer problem: JAMES EWING.

The concentration of isotopes by chemical means: H. C. UREY, H. G. THODE and JOHN E. GORHAM. A 46-fold change in the ratio of the nitrogen isotopes has been effected by the use of the exchange reactions between ammonia gas and ammonium nitrate solution, using a two-stage distillation column as suggested by Urey, Huffman, Thode and Fox.[1] The first column consists of a 1-inch glass tube 40 feet in length packed with glass spirals, and the second column of a $\frac{3}{8}$-inch glass tube 25 feet in length also packed with glass spirals. On the basis of preliminary experiments each of these was calculated to give approximately a 10-fold increase. The two columns produced 14.8 per cent. N^{15} in two weeks, and the concentration was continuing to rise. The transport was about 0.15 grams of N^{15} per 24 hours. A third section, consisting of a 3-inch glass tube 50 feet in length packed with Berl saddles, is being constructed. This should increase the transport by a factor of 10, and should increase the concentration which can be produced at the present time. The concentration of S^{34} has been increased by the use of the $\frac{3}{8}$-inch column. Using the exchange reaction between sulfur dioxide and sodium bisulfite solution, S^{34} concentrates in the solution, and hence the same apparatus can be used for work on this isotope, though probably much smaller changes in concentration can be effected.

Studies in radium poisoning: the metabolic effects of ingested radium in rats: ROBLEY D. EVANS and ROBERT S. HARRIS (introduced by K. T. Compton). Relatively small doses of radium chloride were fed by mouth to 6 young male albino rats of the Wistar strain. Animals receiving 20, 35 and 70 micrograms of radium showed normal growth performance. Their bones, however, became very fragile and fractures occurred during normal handling of the animals. Fifteen months after ingestion of the radium the two animals which had received 35 micrograms and the two at 70 micrograms each developed osteogenic sarcomata. The six control animals show no such tendency. This finding parallels the well-known observation of osteogenic sarcoma in humans who have endured chronic radium poisoning for ten to fifteen years. Efforts are now being made to transplant these new bone tumors to normal animals of the Wistar strain. Quantitative studies of the radium metabolism have been made on all the animals. At the highest dosage level, 98 to 99 per cent. of the ingested radium was excreted by the animals within a few weeks after feeding. The fractional retention decreases markedly with decreasing total dosage, paralleling the new observations on human beings. The radon content of the exhaled breath of the rats represents about 50 per cent. of the total body radium, as in human beings. The average concentration of radium in the rat's

[1] *Jour. Chem. Phys.*, 5: 856–868, 1937.

skeleton is, however, several hundred times greater than the concentration required to produce osteogenic sarcoma in man.

Relationship of humidity to evaporation of sweat: EUGENE F. DU BOIS and JAMES D. HARDY. The rate of evaporation of sweat from the surface of the skin depends upon the difference in vapor pressure of the water on the skin and in the air, assuming constant air motion. The vapor pressure of the sweat may be found from the skin temperature. The vapor pressure of the atmospheric water vapor depends upon the relative humidity and the temperature. The evaporating tendency of sweat may then be computed for any humidity, and the effect of a change in humidity upon perspiration rate studied. From pure physics it is easy to see that a change from 50 per cent. to 100 per cent. relative humidity affects the evaporation rate by only 6 per cent. at 32° F. and only 20 per cent at 60° F. At 95° F., however, such a change will cause complete cessation of evaporation of sweat. If, now, the physiological factor of the rate of sweating be taken into account a clear picture of the actual importance of this change in humidity is obtained. From 32° F. to 86° F. the quiet body has little use for sweating, so that body heat loss is affected only 1 per cent. at 32° F. and 15 per cent. at 86° F. Between 86° F. and 88° F. the importance of humidity increases enormously, and in the quiet body a change from 50 per cent. to 100 per cent. relative humidity determines the matter of comfort or fever. In a moderately active person (walking slowly), the importance of humidity in the lower range of temperature is the same as for the quiet person. However, at 78° F. the importance rises rapidly, becoming 100 per cent. at about 90° F. In a still more active person the sharp increase in importance comes at a lower temperature.

The movement of water from concentrated to dilute solutions through liquid membranes: W. J. V. OSTERHOUT and J. W. MURRAY. In certain models set up to imitate living cells the behavior of water is the opposite of what is expected, for it moves from a concentrated to a dilute solution or from a region of low to one of high activity. This apparent violation of the laws of thermodynamics may continue for months before equilibrium is attained. A movement of water from a concentrated to a dilute solution, so-called "anomalous osmosis," observed with certain solid membranes has been ascribed to the action of pores. But in our models only liquid membranes are employed and no pores exist. The evidence indicates that we have to do with a new phenomenon. The principle may be illustrated thus. Water and guaiacol (o-methoxyphenol) are shaken together until equilibrium is attained. Some of this guaiacol (for convenience called B) is placed in the bottom of a U-tube: resting on this in the left arm A and in the right arm C is some of the distilled water which has been shaken with the guaiacol. The water does not mix with the guaiacol but forms a separate phase. On adding trichloroacetic acid to A we might expect water to move from C to A, but the opposite happens. We find that water and acid move from A to B and from B to C. The higher the concentration of acid in A the greater the movement of water into C. This is because the acid increases the solubility of water in the guaiacol phase and thus causes water to pass from A to B, but when the acid moves from B to C the solubility of water in B decreases and in consequence water goes from B to C. As the freezing point of A is lower than that of C it is evident that water moves from A, where the activity of water is low, to C, where its activity is high. The movement of water vapor through the air in an inverted U-tube above the solutions is from C to A. This appearance of "perpetual motion" can go on for months, ceasing only when A and C become identical in volume and in composition. The increase of water in C may amount to 40 per cent. or more. In view of the surprising nature of this result we thought it desirable to test it in another way, namely, by shaking A with B and then shaking B with C (in both cases the shaking was continued until equilibrium was attained). The result shows an increase of water in C which may amount to more than 400 per cent. Since in certain respects guaiacol acts like some protoplasmic surfaces it seems possible that similar phenomena may occur in living cells. Using acetone in place of trichloroacetic acid the results were somewhat similar but much less striking.

Cellular reactions in sensitization: FLORENCE R. SABIN and A. L. JOYNER. The importance of the reaction of the skin of the tuberculous animal to the injection of tuberculin has long been recognized. For a time it was thought that this sensitivity developed only through the infection; then it was found that it could be elicited with dead bacilli and quite recently it has been induced with tuberculo-protein but only with large amounts. It has now been found that tuberculo-phosphatide enhances the sensitization of guinea-pigs to tuberculo-protein. We consider that this enhancement is at least in part related to the increased cellular reaction brought about by the phosphatide in the presence of protein. The cellular reaction is a local increase in monocytes, the formation of epithelioid cells and a subsequent infiltration of the tissues with eosinophilic leucocytes. The use of two unrelated chemical fractions from the bacillus induces a type of sensitization more like that of the disease both in time and in degree than is brought about by the same amount of protein. The experiments suggest that the monocytes and epithelioid cells play a rôle in the phenomenon of sensitization.

Size of population and breeding structure in relation to evolution: SEWALL WRIGHT. Size of population plays an important rôle in evolutionary theory. The effective size (N) of the theory, may, however, differ much from the apparent size, being usually much less. N obviously refers only to the breeding population. If the numbers (N_m, N_f) of mature males and females are different, N depends mainly on the less numerous sex.

$$\left(N = \frac{4\,N_m\,N_f}{N_m + N_f}\right).$$

The surviving offspring are likely not to be derived at random from the parental generation. With N_o parents furnishing varying numbers (k) of gametes to a next generation of equal size ($\overline{K} = 2$),

$$N = \frac{4N_o - 2}{2 + \sigma_{ik}^2}.$$

Of greater probable importance in nature are cyclic variations in numbers. In a cycle of not too long a period (in generations) the effective size

$$\left(N = \frac{n}{\sum_{i=1}^{n} \frac{1}{N_i}} \right).$$

is controlled largely by the phase of small numbers. A small N permits random fixation of non-adaptive characters and to some extent control by mutation pressure. In a large species, restrictions on interbreeding may permit differentiation of local populations. The variance of gene frequencies (σ_q^2) takes the value $q_t(1-q_t)$ f, where q_t is the mean gene frequency in the species and f is the inbreeding coefficient. In a population distributed continuously over a large area, but with mates always drawn from small groups (size N) the value of f for groups separated by n generations of ancestry (or by $\sqrt{n}$ diameters of the unit area), lies between $\frac{\Sigma}{2N+\Sigma}$ and $\frac{\Sigma}{2N-\Sigma}$ where $\sum = \sum_{x=1}^{n}(1/X)$. This permits considerable fluctuating local differentiation where N is less than a few hundred but leads to approximate fixation of differences only if N is much smaller. In a species, whose range is essentially one dimensional, Σ has the value $\sum_{x=1}^{n} \sqrt{1/X}$. Differentiation increases much more rapidly with distance than in the preceding case. Another mode of attack is appropriate where the range is subdivided into partially isolated territories. As shown previously σ_q^2 here takes the form $q_t(1-q_t)/4N_m + 1)$ where N is the effective size of the local group and m the effective proportion of immigrants from the species as a whole. Both N and m may be much smaller than indicated by actual numbers and amounts of cross breeding with neighboring groups. If small enough, there is random non-adaptive differentiation of local groups. With small m, but not N, there is adaptive differentiation in respects related to differential conditions. These processes may be expected to be supplemented by intergroup selection such that those local groups which happen to acquire combinations of characters of more than local adaptive significance multiply relatively rapidly and supply more than their share of emigrants. The simultaneous action of partial isolation and intergroup selection should result in a more rapid evolutionary process than either isolation alone or intragroup selection alone. Splitting of species requires nearly complete isolation. In some cases (as where translocations become fixed) there is evidence of fixation against very strong selection, likely to occur (in a sexually reproducing species) only if there are numerous outlying territories in which the populations are so isolated and so liable to extinction that the lines of continuity frequently pass through single stray individuals.

The mechanism of hearing as revealed through experiment on the masking effect of thermal noise: HARVEY FLETCHER. In an electrical conductor there is a statistical variation of the electrical potential difference between its two ends, which is due to the thermal agitation of the atoms, including the electrons. This electrical noise is amplified by means of a vacuum tube amplifier and then converted into an acoustical noise by means of a telephone receiver held on the ear. When this noise is present it reduces the capability of the ear to hear other sounds. The intensity per cycle of the acoustical noise compared to the intensity of a pure tone which can just be perceived in the presence of a noise was determined experimentally using a group of observers. This relative intensity for a given frequency range was constant throughout a wide variation of intensity. However, its value does vary with the position in the frequency spectrum, and it is the amount of this variation which enables one to calculate the relation between the frequency of the tone and its position of maximum stimulation along the basilar membrane. The results of such a calculation are given and shown to be in good agreement with determinations from animal experimentation.

(*To be concluded*)

SCIENTIFIC EVENTS

THE MOUNT EVANS LABORATORY

THE Mt. Evans Laboratory, which is sponsored by the Massachusetts Institute of Technology and the University of Denver, will be available to research workers in the field of the sciences during the months of July, August and September. This laboratory is located on Mt. Evans (altitude 14,260 feet) which is 65 miles from Denver by automobile road.

The services rendered by the laboratory are materially enhanced by the availability of the laboratories of the University of Denver and the University of Colorado School of Medicine; stations at altitudes of 11,000, 8,000 and 7,000 feet, respectively, where one may obtain living accommodations and electric power; deep snow-fed lakes at high altitudes, which include Summit Lake on the road to Mt. Evans five miles from the peak; mines and tunnels in and near Idaho Springs, which is at a distance of 15 miles, and the Division of Photography of the Army Air School in Denver. The greatest demand has come from workers in the field of cosmic rays, but there are many problems in science which may be studied at this altitude.

D. K. Froman and J. C. Stearns connected a Ferranti electrostatic voltmeter between a horizontal wire and ground. This wire was supported by two poles to which it was attached by porcelain insulators. The air was ionized by burning splints in tin cans which were affixed to the wire. With the wire six inches above ground the voltmeter reading varied from 0 to more than full scale reading, which was 2,500 volts.