been formed to give preliminary consideration to these more permanent aspects of the board's work, with the expectation that these should become the major responsibilities of the board as soon as the more pressing problems associated with the present emergency have been disposed of.

Many of these activities have already called upon the resources of the National Research Council, and it is evident that this new arm of the academy will result in an increased effectiveness of the academy and the National Research Council as public servants.

PAPERS PRESENTED AT THE CAMBRIDGE MEETING

AT the autumn meeting of the National Academy of Sciences, held in Cambridge, Mass., on November 20, 21 and 22, the following papers were presented:

Relation between positron electron pairs and single positives resulting from gamma ray collisions with atomic nuclei: CARL ANDERSON and SETH NEDDERMEYER (introduced by Robert A. Millikan).

Cosmic ray fluctuations and their interpretations: ROBLEY EVANS, ROBERT A. MILLIKAN and VICTOR NEHER.

Evolution of the expanding universe: G. LEMAITRE (introduced by Harlow Shapley).

The physical background of relativistic cosmology: H. P. ROBERTSON (introduced by Harlow Shapley).

The terrestrial abundance of the permanent gases: HENRY NORRIS RUSSELL and DONALD H. MENZEL. There is a fairly general agreement of cosmic and terrestrial abundances of metallic elements, but a large discrepancy in the abundances of the permanent gases, in particular hydrogen, helium, nitrogen and neon. The obvious inference is that the earth has lost most of these gases initially present, as the moon has lost its atmosphere. An examination of the conditions of escape shows that this could have occurred only if the original temperature of the earth were very high, 5000° C. or greater. The cooling would have been very rapid, and the conclusion seems unavoidable that most of the loss occurred during the first few years if not the first few days of the planet's independent existence, with the loss of hydrogen practically immediate. For substances such as water and carbon dioxide, which may enter into the composition of molten magma, no difficulty arises. Under present conditions no atom could escape if purely thermodynamic conditions prevailed. Collisions of the second kind with excited metastable oxygen atoms could, however, impart to hydrogen and helium atoms velocities sufficient to enable them to escape. That such excited atoms are present is shown by the occurrence of the auroral lines.

Radial stellar pulsations of appreciable amplitude: T. E. STERNE (introduced by Harlow Shapley).

Discussion of magnitudes and colors from the Harvard photographic photometry: CECILIA H. PAYNE (introduced by Harlow Shapley).

The necessity for the existence of magnetic fields associated with sun-spot vortices: D. H. MENZEL and T. E. STERNE (introduced by Harlow Shapley).

Polarization of sun's rays reflected by the moon: F. E. WRIGHT. The percentage of polarization in sunlight reflected by different areas of the moon and at different phases was measured during the lunation, September 1 to October 19, 1933, by a visual method and also by means of a thermoelement and rotatable analyzer. In the visual method a special eyepiece was employed with which the percentage polarization can be ascertained under favorable conditions, to one tenth of one per cent. In this eyepiece a tiltable, plane parallel plate of thin celluloid compensates the plane polarization of the incoming light; a bi-quartz plate serves to rotate the plane of vibration plus 45° in the one half and minus 45° in the second half and to produce a photometric field; a second tiltable plate of thin celluloid is used to introduce a small amount of plane polarized light and thereby to increase the accuracy of the setting, following the practise of B. Lyot; a Savart plate with Nicol or Wollaston prism is employed to detect the presence of polarized light in the compensated beam. The eyepiece was used on the 6-inch refracting telescope of Mt. Wilson Observatory and functioned exceedingly well. The results obtained are shown in a series of tables and graphs. Discussion of the data of measurement, together with a comparison of the results of measurements on terrestrial materials, indicates, in agreement with previous work, that the lunar surface materials are of the nature of volcanic ashes and pumice.

Sun-spots and weather: CHARLES G. ABBOT. In the year 1908, Dr. George E. Hale at Mount Wilson Observatory discovered magnetism in sun-spots. He soon found that magnetic polarities are opposite in adjacent spots. Following up the investigation, it was disclosed that the order of the two polarities is opposite in the north and south solar hemispheres and that the order continues unchanged through each eleven-year sun-spot period, but reverses at the beginning of the next period. Thus it requires two eleven-year periods to bring the sun through a full cycle of magnetic changes. In 1931, the author discovered periodicities of approximately 7, 8, 11, 21, 25, 45 and 68 months in the variation of solar emission of radiation. Indications were found that these periodicities are reflected in terrestrial temperatures. Since November, 1932, assisted by Mrs. A. M. Bond, he has studied these periodicities in the departures from normal temperature at Bismarck, N. Dak. Although they are clearly present, changes of phase and amplitude occur in long ranges of time which hinder their usefulness for forecasting purposes. He has discovered that these changes of phase and amplitude in these periodicities of variation from normal temperatures at Bismarck, N. Dak., are functions of the numbers of sun-spots prevailing. The times of maximum in some periods are set forward by as much as half a period in passing from sun-spot minimum to sun-spot maximum. He attempted with some success to forecast temperature departures by combining periodicity and sun-spot data, but a better

method disclosed itself. He noted that when plotted according to Hale's double sun-spot period the principal features of the temperature departures of Bismarck, N. Dak., showed strongly a tendency to repeat themselves. At it was immediately seen that the true interval for each repetition was 23 years, or 276 months. He perceived that the periodicities in solar variation approximately fixed by him several years ago were nearly submultiples of 276 months. Thus dividing 276 by 3, 4, 6, 11, 13, 15, 18, 25, 34 and 39, we have 92, 69, 46, 25-1/2, 25-1/11, 21-3/13, 18-2/5, 11-1/25, 8-2/17 and 7-1/13 months, of which the second, third, fifth, sixth, eighth, ninth and tenth values are closely approximating to the periodicities announced by him as existing in solar variation. Moreover, all the intervals thus deduced appeared to continue over long intervals in the departures from normal temperature of Bismarck, N. Dak., if, as above stated, attention is given to the sun-spot numbers prevailing. He thereupon conceived that since all the periodicities were submultiples of 23 years, the tedious method of determining periodicities individually might be omitted, and their combined effect might be found by discussion of a 23-year cycle. This proved highly successful. At Bismarck, N. Dak., the monthly mean departures from normal temperature for two periods, 1875 to 1898, and 1898 to 1921, gave features of great similarity. It was found, indeed, as was expected, knowing the irregularity of sun-spots, that the principal features were subject to shiftings of several months, due to changes of phase of constituent periodicities. This was allowed for by using slightly flexible scales of abscissae, alternately expansible and compressible in slight degree, when combining the two 23-year periods. When averaged with these slight adjustments and plotted as a prediction for the interval 1921–1933, the curve of forecast very closely represented the observed march of departures from normal temperature for those twelve years. He then represented in percentages of the monthly mean normal precipitation the observations at Bismarck, N. Dak., for the range 1875 to 1921, thus covering two 23-year cycles. Based thereon, he made a similar forecast of percentage precipitation 1921–1933, which proved to be in close accord both as to magnitudes and features with the observed values. The method is fortunately even more useful for forecasting precipitation than for temperature. Its inexactness is believed to be due to the difficulty of forecasting irregularities in the appearance of sun-spots, and allowing for their effects upon the phases of the component periodicities of variation. Many other stations are being studied. So far as completed, the results confirm the impression that in the 23-year cycle lies the key to long-range weather forecasting. The present paper is preliminary. The author hopes, however, within a few months to be in a position to announce a forecast of temperature and precipitation for numerous stations in all parts of the world for many years in advance. In so doing, he expects to prove that the principal agent in producing variations from normal weather (or climate) is the variation of the sun.

A direct determination of the atomic weight of the electron: R. C. GIBBS and R. C. WILLIAMS (introduced by F. K. Richtmyer).

Limiting current density in ionized gases: ALBERT W. HULL.

The mechanism of cosmic ray counter action: CARL ANDERSON, ROBERT A. MILLIKAN, SETH NEDDERMEYER and WILLIAM PICKERING.

The evaporation and sputtering of thorium from thoriated filaments: IRVING LANGMUIR. The rate of evaporation of electrons, ν_e, (electron emission) from a thoriated tungsten filament depends on the temperature T and on θ, the fraction of the surface covered by thorium atoms. The relation of ν_e to θ and T has been given by Brattain and Becker (*Phys. Rev.*, 43: 428, 1933). From ν_e the change in contact potential V of the filament surface produced by the adsorbed thorium can be calculated by the Boltzmann equation. Knowing σ, the number of thorium atoms per cm², the dipole moment M of each is given by $V = 2\pi\sigma M$. By an equation already used for Cs films on tungsten (I. Langmuir, *Jour. Amer. Chem. Soc.*, 54: 2822, 1932) the 2-dimensional equation of state of the adsorbed film can be calculated from M. Then by Gibbs' adsorption equation the relation of the atom evaporation rate ν_a to θ and T can be determined. It is thus calculated that in the range from $\theta = 0.2$ to $\theta = 0.6$, ν_a varies in proportion to $\varepsilon^{H\theta}$, where $H = 8.1$ in good agreement with the value of $H = 7.8$ given by Brattain and Becker's measurements. A recalculation of the data of numerous experiments in 1921–1923, using the new relation of ν_e to θ, gives data on ν_a as a function of T and θ in good agreement with the values of ν_a calculated from ν_e. A similar recalculation of the data of Kingdon and Langmuir (*Phys. Rev.*, 22: 148, 1923) on the sputtering of thorium from thoriated filaments by ions of various gases leads to new conclusions. The rate of removal of Th is found to be accurately proportional to θ. A new mathematical theory of sputtering is developed, based on the hypothesis that sputtering is purely thermal evaporation from the small areas which are momentarily heated by the ion impacts. The variation between the observed rates of sputtering by high velocity ions is accounted for wholly by differences in the depth of penetration of the ions. The absolute magnitude of sputtering, as well as its variations with voltage, even down to the threshold voltage at which sputtering begins, is satisfactorily given by this theory.

The use of ground and etched crystals in x-ray spectrometry: F. K. RICHTMYER and F. W. BARNES.

Rocking curves obtained by transmission of the x-ray beam through calcite crystals: T. R. CUYKENDALL and S. W. BARNES (introduced by F. K. Richtmyer).

Muscle Shoals and the Tennessee Valley problem: ARTHUR E. MORGAN.

Biological variations in sugar utilization: THORNE M. CARPENTER (introduced by Francis G. Benedict). Canaries and rats were given glucose, fructose and galactose in amounts comparable to those used in previous studies with humans when the total metabolism without food was used as a basis. The gaseous exchange with particular reference to the respiratory quotient was fol-

lowed for three to five hours after ingestion of the hexoses. The results obtained did not resemble those found with man with all three sugars, nor did the rats and the canaries give values resembling each other with all three sugars. The findings indicate that there are distinct biological variations in the metabolism of carbohydrates.

The gaseous metabolism of some dwarfs and giants: ALLAN WINTER ROWE (introduced by Francis G. Benedict). During a recent professional engagement an opportunity presented for a partial metabolic study of a group of dwarfs consisting of four women and one man. In addition, an acromegalic giant, also a member of the troupe, was somewhat more thoroughly investigated. The present report deals with the individual energy metabolism as measured by the oxygen exchange. The estimation of the normality of the respiratory metabolism of the group offers an interesting problem as the dwarfs had the physical stature and sexual immaturity of young children, while their chronological ages ranged from 18 to 34. Analysis is made of the several prediction standards, and the applicability of each to the individual subjects in the series is discussed. The results of earlier investigations on two previously studied patients were added to bridge the gap between the dwarfs and people of normal height. These latter were both adult women of small but not dwarfish stature who had never matured. One was a pituitary case as were the group of the dwarfs; the developmental arrest of the other derived from a congenital luetic status. Depressed basal rates were the rule; in each case, however, a summary of the results of comparison of the observed rate with the several prediction standards reflected the physical and functional status which had engendered the specific somatic abnormality. The extremes of height were, respectively, 95.0 and 228.6 cm.; of weight, 16.3 and 163.3 kilograms; of area, 0.639 and 3.125 sq. meters; and of oxygen consumption, 79.0 and 419.7 cc. per minute. With the exception of the one control case noted above the energy metabolism showed a definite downward trend which in the case of certain comparisons showed deviations as low as -44%.

Necessary versus optimal intake of vitamin G (B_2): H. C. SHERMAN and L. N. ELLIS. Somewhat as has been indicated by the work of others with vitamins A and C, though by the use of different methods and criteria, it is here found that the amount of vitamin G required for optimal results in nutrition is much above that which is demonstrably necessary for the prevention of any sign of specific deficiency or even for the support of good growth. Thus there is advantage in an intake considerably higher than that which appears to be strictly necessary; and the difference between the minimum which suffices from the qualitative point of view and the amount which yields the best results, when studied by comprehensive quantitative methods, is found to be relatively wide. The work here reported covered that part of the life-cycle of the original experimental animals (rats) which lies between late infancy and the completion of the breeding record, together with observations on the early growth of the offspring. The improvement which here resulted from the enrichment in vitamin G of an already adequate diet was chiefly apparent in the superior vitality of the young; but these experiments did not extend over the latter part of the life cycle. The vitamin G intake was varied systematically by quantitative adjustments among the ingredients of a dietary in which the vitamin was furnished in the form of natural food. This plan was adopted partly because in the state of knowledge existing when these experiments were begun, the attempt to devise a more synthetic diet might have led to deficiencies of unknown essential substances, and partly because sufficient amounts of purified concentrates to feed the number of animals needed in such experiments would have been prohibitively expensive to prepare. In the light of the results of simultaneous work and with the aid which is now being given by the Carnegie Corporation of New York through the Carnegie Institution of Washington, it is hoped that experiments can be made with vitamin G as a more nearly isolated factor and that such experiments can be continued throughout the natural lives of the experimental animals. It seems desirable definitely to ascertain whether and how vitamin G functions as one of the chemical factors in the relation of food to the length of normal life.

The nature of the depressor substance of the blood: CYRUS H. FISKE (introduced by O. Folin).

The nerve path of infection in poliomyelitis and its significance: SIMON FLEXNER. While this communication relates specifically to poliomyelitis, it applies in principle to still other infectious and inflammatory diseases of the brain and spinal cord. The experiments were made on *Macacus rhesus* monkeys, in which the virus of poliomyelitis induces a paralytic disease indistinguishable from the epidemic disease occurring in man. The infection is produced by instilling the virus—a suspension in salt solution of the spinal cord of a paralyzed monkey—into the nose. From seven to ten days after the instillation, symptoms of infection arise, increase in intensity and terminate in wide-spread muscular paralysis. The virus gives rise to no detectable pathological changes in the nasal mucous membrane. It possesses an affinity for the olfactory nerve cells—the organ of smell —which lie exposed in this membrane. The hairlike processes (dendrites) of these cells project into a layer of mucus which the virus enters to come in contact with the cells. The dendrites take up the virus and pass it on, by way of the axon or nerve fiber, to the olfactory lobe of the brain, whence it passes on still further, by nerve connections, to more distant parts of the brain and spinal cord. As the virus travels it becomes affixed to the motor nerve cells which control voluntary motion, injures them and thus induces muscular paralysis. Other cellular changes, secondary and reactive in nature, are also induced in the nervous organs. Hence the olfactory nerves carry the virus from the periphery (nasal membrane) to the brain, and they also carry it in the reverse direction from the center (brain) to the periphery. This two-way transport has been shown for the first time in connection with the virus of poliomyelitis. The olfactory nervous structures are to a considerable extent iso-

lated from the blood and lymph, which carry the protective, immune substances effective against impending infections. They afford, therefore, potentially a ready means of penetration of the virus into the central nervous system. It is only after the virus has reached the brain that the cellular reactions in the system, detectable by microscopic and chemical examination of the cerebrospinal fluid, make possible the escape of these protective substances. This phenomenon is more strongly marked among children than among monkeys, which probably accounts for the occurrence of many cases of mild poliomyelitis among children and few among the experimentally infected monkeys. The influence of the isolation of the olfactory nerves is observed in monkeys artificially immunized to the virus. These monkeys may be protected against the paralyzing effects of the virus injected into the brain, and yet respond with paralysis to virus instilled into the nose. Although this report deals only with experimental poliomyelitis, evidence exists showing that other viruses having a strong affinity for the central nervous organs utilize the exposed olfactory nervous structures in the nasal membrane in order to reach the nervous system. The origin of certain epidemic, nervous diseases of the higher animals is becoming explicable in this way.

Tumor-inhibiting factors extractable from tissues: JAMES B. MURPHY (introduced by Simon Flexner). It has proved possible to separate a substance from chicken tumor extracts which, if brought to a proper concentration, is capable of neutralizing the tumor-producing properties of the transmissible agent in its most active form. Furthermore, this factor from the chicken tumor is equally effective in inhibiting the growth of certain transplantable mammalian sarcomas, but is without effect on carcinomas. On the assumption that this inhibitor is related to the factor which controls normal growth of cells, a number of tissues have been tested for tumor-inhibiting properties. So far placenta and embryo skin extracts have yielded fractions having a distinct retarding effect on transplantable carcinomas. The present report deals with the action of these same normal tissue fractions on the course of natural or spontaneous cancer of mice. Their inhibiting action is evident not only on local post-operative recurrences of the disease and on the growth of autografts where there is direct contact between the extract and the cancer cells, but is definitely observable when the test fluids are injected at a distance from established tumors. While the results seem to substantiate the suggestion that the inhibitor from tumors is similar to the balancing factor of normal tissues and would give a possible insight into the mechanism involved in malignancy, the materials utilized are too complex to justify a conclusion at the present time.

The use of hypertonic sucrose solution to reduce cerebrospinal fluid pressure without a secondary rise: L. T. BULLOCK, R. KINNEY and DR. M. I. GREGERSEN (introduced by Walter B. Cannon). Both clinical and experimental evidence proves that the use of hypertonic sodium chloride and glucose solutions for reduction of cerebrospinal fluid pressure is followed by an undesirable secondary rise in the pressure. We have attempted to overcome this undesirable effect by using sucrose. When injected intravenously, this substance is non-toxic, has a high osmotic pressure and is quantitatively excreted by the kidney, together with a considerable volume of body water. In experiments performed on dogs under sodium amytal anesthesia, cerebrospinal fluid pressures were taken in the cisterna magna for 10 to 13 hours. Continuous blood-pressure records were obtained from the femoral artery; urine volume, respiration, heart rate and rectal temperature were noted every 15 minutes. A 50 per cent. sterile sucrose solution was injected intravenously at 5 cc per minute in doses of 3 to 8 grams per kilo body weight. Control experiments without sucrose injection all showed a slow, steady rise of cerebrospinal fluid pressure during the period of observation. There was also a moderate increase in the number of white cells in the spinal fluid. This increase was not produced by sodium amytal alone. In experiments with sucrose the normal control pressure was observed for 1 hour or more prior to the injection. The maximum reduction of cerebrospinal fluid pressure occurred within an hour after injection began. The extent of the reduction (50 to 150 mm of Ringer's solution) was dependent upon the amount of sucrose given and upon the height of the initial pressure. Seemingly, the effect was greater with higher initial pressures. The fall of cerebrospinal fluid pressure was followed during 5 to 7 hours by a gradual rise, occasionally to normal but more frequently to a subnormal plateau. Although the pressure was often observed for 12 hours after injection, there was no indication of the beginning of a secondary rise, except in 3 experiments. In these the terminal rise could be ascribed to definite causes other than sucrose. Injection was followed by a period of active diuresis lasting 3 hours, during which most of the sucrose was eliminated together with a volume of urine 4 times the volume of fluid injected. With doses of 6 grams per kilo, the body fluid lost through the kidney was 4 to 5 per cent. of the total body weight. The absence of a secondary rise of cerebrospinal fluid pressure after sucrose may be explained by the excretion of the agents necessary to produce it, namely, the injected substance (sucrose) and free water. Experiments with sodium chloride and glucose under the same conditions confirmed the experience of other investigators that both substances, more especially sodium chloride, produce a terminal rise of pressure which far exceeds the original level.

Central excitation and inhibition in reflex changes of heart rate: ARTURO ROSENBLUETH (introduced by Walter B. Cannon). Reflex changes of heart rate on afferent maximal stimulation at varying frequencies of the depressor, the left vagus and the sciatic were recorded from cats with either the vagi or the accelerators severed. These responses were compared with those obtained from peripheral maximal stimulation of either the right vagus or the right accelerator. The time-course of the responses was followed by plotting the reciprocal of the intervals comprised by a given number of beats against the corresponding times. The subsidence of central ex-

citation and inhibition in these reflexes may be very long (up to 10 minutes). The maximum of the reflex responses at equilibrium is a continuous function of the frequency of afferent stimulation. The reflex output of the centers is lineally proportional to the excitatory input. For a given degree of tonic activity, the output is a continuous, non-linear function of the inhibitory input. The duration of the subsidence of the reflex responses is a continuous function of the afferent frequency. This subsidence is not explained satisfactorily by the hypothesis of reverberating delay paths. The data presented are hard to reconcile with any physical theory for central excitation and inhibition, whereas they are readily explained as follows. Nerve impulses impinging on a neurone give rise to quanta of an excitatory (c.e.s.) or an inhibitory (c.i.s.) substance. Both c.e.s. and c.i.s. are destroyed at a rate proportional to the concentration. For a steady input and at equilibrium the concentrations of c.e.s. and c.i.s. are proportional to the afferent rate. The output of a neurone is proportional to the concentration of c.e.s. The reflex output is therefore lineally proportional to the excitatory input. C.i.s. combines with c.e.s., inactivating the latter. This combination follows the law of mass-action. The degree of inhibition, as shown by the decrease in output, is therefore not lineally proportional to the inhibitory input.

The recovery period of the auditory nerve and its significance for the theory of hearing: HALLOWELL DAVIS, ALEXANDER FORBES and A. J. DERBYSHIRE (introduced by Walter B. Cannon). One type of auditory theory assumes that the frequency of sound waves is transmitted to the higher nervous centers as a corresponding frequency of nerve impulses in the auditory nerve. To account for the perception of high-pitched tones on this basis it has been suggested that the auditory nerve may have a much briefer recovery period than other mammalian nerves, which might permit of frequencies of impulses as high as 10,000 per second. No direct measurements of the recovery period of this nerve have been made, due to anatomical and technical difficulties. We have succeeded, however, in measuring it by an indirect method. If action currents are led from the auditory nerve by suitable coaxial electrodes which exclude the direct microphonic response of the cochlea and are measured on a cathode ray oscillograph, it is found that their size is roughly constant in response to maximal auditory stimulation at frequencies of 700 and below. The frequency of the action current waves corresponds exactly to that of the stimulating sound. Between 700 and 900, and quite sharply in any given preparation, the size of the action currents falls to approximately one half of this value. A second, though less spectacular drop, is usually seen at about 1,700. The frequency of the stimulating sound may still be detected in the response up to 2,800 per second but no higher. The closely synchronized waves have been gradually replaced by completely asynchronous impulses. Calculations from the known refractory period of nerves at body temperature show that a nerve might follow the rhythm of stimulation up to perhaps 900 per second. Our measurements indicate that this occurs in the fibers of the auditory nerve. The sudden reduction in size of response at about this frequency undoubtedly means that each individual fiber has begun to respond only to alternate sound waves. Since only half the fibers respond to a given wave, the size of the response is half as great as before. The next reduction at 1,700 represents a breaking into three groups, while at 2,800 the responses become completely irregular. This alternation of activity, succeeded by irregularity, has already been described by one of us as characteristic of the response of excised peripheral nerves stimulated electrically at high frequencies. We conclude that the auditory nerve is in no way unique in respect to its ability to transmit high frequencies of impulses but has a functional recovery period of at least 1.1 σ. Furthermore, even by virtue of rotation of activity the frequency of stimulation is not represented centrally above 2,800 per second. Therefore, pitch discrimination for high tones must depend upon some selective activity in the cochlea and not involve the frequency of nerve impulses. For tones of low pitch, however, a frequency theory is still possible.

The functions of the premotor area of the cerebral cortex: J. F. FULTON (introduced by Raymond Dodge).

Ocular-rotation centers for the two primary axes: WALTER R. MILES.

Loss of virulence in the protozoön of "blackhead," a fatal disease of turkeys, and the immunizing properties of attenuated strains: ERNEST EDWARD TYZZER (introduced by E. B. Wilson). The disease to which the rather inappropriate name "blackhead" has been applied is of wide occurrence in gallinaceous birds, and has been found in the quail, prairie-chicken, heath-hen and ruffed-grouse, as well as in the turkey. The infection is widely prevalent in common chickens but, not being seriously affected, they become carriers and evidently serve as the chief source of infection. The pioneer work on this infection was done by Theobald Smith, who in 1895 discovered the causal agent, which is a protozoön, *Histomonas meleagridis,* and made other important contributions to the knowledge of the disease. Following a period of years devoted to the study of sources of the infection and modes of its transmission, the present investigation deals with changes in the character of this protozoön, when grown for long periods in culture medium. On being propagated outside the body of the bird, the protozoön gradually loses virulence, remaining infective for young turkeys and other birds, but no longer producing serious disease. Young turkeys infected through inoculation with attenuated strains are protected against virulent strains of the protozoön which are almost 100 per cent. fatal to unprotected birds. Once vaccination is accomplished, continuous exposure to virulent infection furnishes the most complete protection. Under long cultivation, the immunizing properties of a strain of Histomonas may in turn be lost. While our evidence is by no means complete, there is much to show that the immunity resulting from infection with attenuated strains of Histomonas is brought about by slight and transient

invasions of the host tissues, which are not sufficiently progressive to produce the gross lesions of disease. Under continued propagation on culture medium, there is evidently a further loss in the invasive properties of the protozoön and it may now fail to immunize completely. While it is possible that these results may lead to a method of vaccinating turkeys against blackhead, there are at the present time serious practical difficulties that prevent the adoption of the procedure for commercial purposes.

Active and passive immunization in typhus fever: HANS ZINSSER and M. RUIZ CASTANEDA.

The schizophrenic psychosis with special reference to homeostasis: R. G. HOSKINS (introduced by E. B. Wilson).

Polyisomerism and anisomerism in cranial and dental evolution among vertebrates: WILLIAM K. GREGORY.

Mutation rate increased by aging seeds as shown by pollen abortion: J. L. CARTLEDGE and A. F. BLAKESLEE. Up to the present time the most consistent method of inducing hereditary changes in plants and animals has been through the use of radiations such as radium and x-rays. The recent findings of Navashin that root tips of Crepis plants grown from old seed show an excessive number of chromosomal abnormalities suggested that aging seed might induce changes that could be inherited. Tests this past summer have in fact shown a definite influence of age of seed upon the number of mutations in the common jimson weed (*Datura stramonium*). Pollen abortion was used as an index of the mutation rate, and ranged from about half of one per cent. of plants affected from one-year-old seed to nearly 10 per cent. of plants affected from seed seven to eight years old. In mutation experiments with radium and x-rays, pollen abortion has proved the most convenient and the most delicate measure of mutation rate. The abortion in some cases is due to chromosomal mutations which, when heterozygous, may cause the disintegration of definite proportions of the pollen grains. In other cases the abortion is due to single genes, causing half of the pollen grains to be defective. From differences in the appearance of the abnormal grains it is usually possible to distinguish between the aborted grains due to chromosomal and those due to gene mutations, as has been previously shown by cytological and breeding tests. A plant develops from several initial cells in a seed, and in any one of these a mutation may occur. Hence different branches of the same plant may differ in respect to pollen abortion. In order to test the effect of aging seeds of Datura, plants of the Standard Line 1 were grown from seeds up to ten years old, and two flowers from each plant were examined for pollen abortion. Gene and chromosomal mutations were found in approximately equal numbers, and the mutations increased about in the order of one per cent. per year. Thus 331 plants from seeds less than one year old gave two mutations (0.6 per cent.), while 3.7 per cent. were found in 872 plants from seeds 3–4 years old, and 8.7 per cent. in 242 plants from seeds 7–8 years old. No plants from 8–9 year old seeds were tested. One hundred plants from 10 year old seeds gave the somewhat lower rate of 7.0 per cent. mutations. While on the whole the percentage of germination is lowest in the oldest seeds, this percentage varies considerably among the progenies of individual parents within each age group, and seems to have no close relation to the number of mutations thrown. The increase in number of mutations is not due to the selective elimination of normals. As far as is known, the seeds were not exposed to any unusual source of radiations, so that this factor seems to be ruled out as the cause of the increased mutation rate. These experiments on Datura form a confirmation of the work of Navashin on the root tips of Crepis plants grown from aged seeds. They deal with a different species and with a part of the plant more closely connected with the hereditary mechanism. In the experiments of Navashin and Shkvarnikov, increased temperatures produced the same effects as aging seeds. It is not as yet clear what the ultimate mechanism may be that thus brings about genetic changes in aged and heated seeds. Presumably the increased temperature and time work indirectly; the former accelerating events which take place within the seed, the latter giving an opportunity for the accumulation of mutations. The definite influence of age and heat upon stored seeds is of interest from its possible relation to the problem of evolution in nature.

Combined sound and light distributor: GEORGE O. SQUIER. The last "half-century of progress" has witnessed the birth and development of electrical communication by sound and power distribution of light. The next logical step forward will be to combine these utilities into single units of heroic models for our parks and superhighways, and also artistic interior combinations for the home. The metal aluminium is the third most prevalent in the earth's crust, and the present trend indicates that the next "half-century of progress" will register a wonderful development of artistic cast, rolled and extruded models of this regal element in wide applications both outside and inside our homes. The "Fountain of Science," by Mrs. George Woodruff, which has been presented to the fair, should remain *in situ* where it now adorns the Science Building. In architecture, with two exceptions, the entire sky-line of the lake front in Chicago did not exist at the time of the Columbian Exposition in 1893. The basic design of A Century of Progress entirely abandons this plan and is developed upon low horizontal lines in the extreme, with but a few elevations which can hardly be described as towers. In future, with a 99 year lease on a city block, the "optimum height" will likely turn out to be less than a dozen stories. The Art Institute of Chicago, which is a part of A Century of Progress, is exclusively art without science; the Hall of Science, under the same management, is exclusively science without picture art. If Whistler's "Mother" had been hung in the balcony library of priceless scientific books, in the Great Room of the Science Building, and Arcturus made to ring beautiful chimes daily at the top of the Grand Stairway of the Art Institute Building, many more thousands of

visitors would have returned to their homes with better knowledge and understanding of both of these key centers of the great fair. Men began to develop art without science. They ended up with science without art. The future must aim to combine the five branches of art—painting, sculpture, architecture, music and poetry—with science into balanced units of transcendent beauty.

A geologic section of the Quabbin aqueduct in central Massachusetts: CHARLES P. BERKEY and FRANK E. FAHLQUIST.

Eocene primates from California: CHESTER STOCK (introduced by John C. Merriam). Two new primate genera belonging to the family Tarsiidae (Anaptomorphidae) are recognized among the fossil mammals now being recorded from the late Eocene Sespe deposits of the Simi Valley region, Ventura County, California. One type, found in association with a very late Eocene fauna, is related to the genera *Omomys* and *Hemiacodon* from the Bridger formation. It represents the latest primate to be recorded from the North American Tertiary. The second type, found with a late Eocene fauna at a locality approximately 900 feet lower than the very late Eocene stage in the Sespe deposits, is related to and possibly derived from the Bridger genus *Washakius*. The Californian species extend considerably the known areal distribution of this lemuroid group in North America, since previously described forms have all been recorded from the intermontane basins of the Rocky Mountain region.

Present status of the problem of the antiquity of man in North America: JOHN C. MERRIAM. Recent advances are based on widely distributed discoveries in paleontology and archeology, with important contributions through geologic correlation, geomorphology and glaciology. Available data regarding occurrence indicate increasing closeness of approach to the present age by faunal types considered characteristic of the Pleistocene, also more extended range of human skeletal remains and artifacts into deposits preceding those characteristic of the present epoch. Association of artifacts with apparently undisturbed remains of extinct animal types, such as ground sloth and other forms characteristic of the Pleistocene, suggests the presence of man at a time earlier than has been generally assumed for North America. The nature of the skeletal remains and the character of the artifacts found have not in themselves required the assumption that they represent relatively early stages in human evolution. The precise geologic dating of most deposits in which this mingling of types occurs is still a problem for careful discussion.

Association of artifacts with mammoth and bison in eastern New Mexico: EDGAR B. HOWARD (introduced by John C. Merriam). Association of artifacts with bones of extinct animals in eastern New Mexico indicates that man was contemporaneous with the extinct elephant and bison in that region. Old lake beds revealed quantities of bison and elephant bones at what appears to have been the old surface of these lakes, where well-chipped spear-points and knives and scrapers were found. In two localities charcoal and burned animal bones were found together with artifacts below the old surface. One of these hearths was several feet below the levels of the bison and elephant bones. Many of the spear-points are similar to the so-called Folsom points; others are as well made but with a dorsal ridge, instead of grooves along the faces. Work carried on by the University Museum for several years previously turned up evidence in line with the associations mentioned above. In a cave near Carlsbad, New Mexico, among other things, musk-ox and bison bones were found in a bed of charcoal and ashes with a grooved point, all at a level four feet below a Basket Maker burial. These facts, in the light of reports of a similar nature from other regions of the country, make it appear that man must have existed at the same time as these extinct animals. When this was is still to be determined.

An investigation of the stresses in longitudinal welds: WILLIAM HOVGAARD. This paper is a report on a theoretical and experimental study carried out during the last four years at the Massachusetts Institute of Technology. It begins with a brief account of research made by the author, already reported, at least partly, in the Proceedings of the National Academy in 1930 and 1931. That work was preliminary and suggested a more complete study of the stresses in the structures which were connected by the weld. The first attempt in this direction was a thesis for the master's degree prepared under the direction of Dr. Heinrich Hencky by three of the students in the course of naval construction. It dealt with the case where a reenforcing web is connected by a spot weld at each end to a continuous plate subject to a longitudinal pull. Only the stresses in the plate, but not in the web, were studied. The next attempt was a thesis for the degree of doctor of science prepared partly under the direction of Dr. Hencky by Y. C. Yeh, a student in the course of naval architecture and naval construction. In this case the welds extended the whole length of the web and the state of stress in the web as well as in the plate was investigated. First the shearing stress in the weld was found by known methods for a plate and web of infinite extent. Employing elliptic coordinates the form of stress function F was developed by the method of complex integration, whereupon stresses and displacements could be found for the infinite plate and web. Correction for the presence of the finite boundaries was made by adding several stress functions to those for the infinite plate and web, each of which functions satisfied the biharmonic equation $\nabla^4 F = 0$ as well as the boundary conditions. Dr. Yeh also gave the solution for a tapered web and for various thicknesses of plate and web as well as for variation in the modulus of elasticity. Finally, an extensive experimental study of the stress field in the specimen analyzed by Dr. Yeh was made by two students, one of naval construction and one of naval architecture in a thesis for the degree of master of science. The results checked very well with the theoretical formulas. According to Dr. Yeh's formula for the shearing stress in the weld, the stress goes to infinity at the ends of the web. The author proposes a modification of this formula,

by which the maximum stress is limited to that at the yield point, such as actually must be the case.

Dielectric properties of crystals: HANS MÜLLER (introduced by J. C. Slater).

Chemical structure and optical activity: P. A. LEVENE and ALEXANDRE ROTHEN.

Contrasting properties of ions, zwitterions and uncharged molecules: EDWIN J. COHN (introduced by J. B. Conant).

A development of a theoretical basis for the behavior of controlled time-temperature curves: EVALD L. SKAU and WENDELL H. LANGDON (introduced by F. G. Keyes). Assuming that a homogeneous and perfectly conducting sample is so arranged that it can lose or gain heat only by radiation to or from the surroundings so that Newton's law of cooling is applicable, and assuming that the temperature of the surroundings is raised or lowered at a constant rate, the following propositions have been proved analytically. I. That if the specific heat of the sample is constant with respect to the temperature the temperature difference between the sample and the surroundings approaches the constant value $\frac{C_p}{K}\frac{d\theta_s}{dt}$, where C_p is the specific heat of the sample at constant pressure, K is a constant of the apparatus, and $\frac{d\theta_s}{dt}$ is the rate of change of the temperature of the surroundings with respect to the temperature. II. That if now the specific heat of the sample begins to increase progressively with the temperature (so as to be concave upward) the time-temperature curve for the sample then becomes concave downward in case $\frac{d\theta_s}{dt}$ is positive, *i.e.*, in the case of a heating curve.

Demonstration of high-speed photography of motions of animals and insects: H. E. EDGERTON and K. J. GERMESHAUSEN (introduced by K. T. Compton). A short reel of motion pictures illustrating the use of high-speed motion pictures for analyzing the motions of biological subjects was shown after the particular method of taking the photographs was described. The camera used for taking these pictures uses stroboscopic light as a source of illumination of a period sufficiently short to effectively stop the object being photographed and to take the pictures on the continuously-moving film without blurring. The motion pictures showed a cat turning over in mid-air after being dropped upside down (500 frames per second), a snake's tongue in action (250 frames per second) and a house fly in action (6,000 frames per second).

A solution of the Poincaré continuation problem: MARSTON MORSE.

Boolian algebras and their applications to topology: MARSHALL H. STONE (introduced by G. D. Birkhoff).

SCIENTIFIC EVENTS

CONSTRUCTION AT THE BELTSVILLE EXPERIMENT STATION

ALLOCATION of more than $1,750,000 of funds for new construction on government property near Beltsville, Md., as a part of the public works program will enable the U. S. Department of Agriculture to develop there a model experiment station for agriculture.

For years the department has been making plans for equipment that would facilitate research on numerous agricultural problems. This work has been conducted heretofore at scattered stations in the vicinity of Washington, D. C. The present building program—designed primarily to relieve unemployment—provides a scheduled stage of construction for July 1, 1934, which is years ahead of progress that would have occurred in the normal course of events. Plans likewise involve the acquisition of about 1,000 acres of land to consolidate government property now in two tracts.

The largest single construction unit will be the new three-story animal-husbandry laboratory. It will provide about one million square feet of floor space and will house a group of laboratories dealing with animal nutrition, genetics, meat and wool investigations and scientific studies involving small animals. This building will cost about $450,000 and will permit an economy and thoroughness in animal husbandry research more nearly compatible with the needs of the many cooperative projects with states and other agencies which center at Beltsville.

For moving the facilities of the Bureau of Animal Industry Experiment Station from Bethesda, Md., to Beltsville, $265,000 has been allowed. This fund will provide a number of small buildings required for the proper isolation and quarantine of many of the animals kept under test and observation in studies of disease.

The poultry-nutrition laboratory, constructed last year, also is modern and will be supplemented by new buildings which will make the plant one of the best equipped poultry research stations in the world.

The field station of the Zoological Division of the Bureau of Animal Industry provides a place for so-called second-stage investigations of parasites. The first-stage studies are carried out at Washington, D. C. The present plans call for a laboratory with rooms and facilities for insectaries, aquariums and vivariums of various sorts for raising suitable hosts of worm parasites.

The $158,300 granted to the Bureau of Dairy Industry will provide for the construction of nine new