Council Committee on Salt Requirements of Plants) each plant would receive 57 c.c. per day.

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MARCH 23, 1922

NOTE ON THE SYNTHESIS OF ETHYL BUTYRATE IN EGG SECRETION

IN our analyses of egg secretion, Miss Woodward[1] and I[2] have isolated an enzyme of the lipase group. The material, precipitated as a white powder, is soluble in both sea-water and fresh. In the presence of this "lipolysin," droplets of egg fat decrease in diameter while the hydrolysis of other neutral fats and the cleavage of ethyl butyrate are measurably accelerated.[3]

Since lipolysin is a parthenogenetic agent;[1, 4] since the unmodified egg-secretions also have parthenogenetic[5] and lipolytic[3] powers; and finally, since eggs with secretions removed by brief exposure to charcoal are completely sterile,[3] it seems likely that lipolysis plays some rôle in the normal initiation of development.[1] However, the evidence that egg-secretions have these powers is still incomplete. It has not been reported whether, under conditions significant for fertilization theory, the effects already observed are reversible.

Accordingly, I prepared egg-secretion as free from contamination as possible and used chloroform to inhibit bacterial action. To 10 or 15 c.c. of this, I then added, in one set of experiments, .5 c.c. of absolute ethyl alcohol; in another, 5 c.c. of 2N. Butyric acid was introduced last of all. The final concentration of the acid was roughly .25 N. and .4 N.

The acidity of the systems was, of course, immediately reduced by the salts present in both the secretion and the sea-water. Under the circumstances then, the loss in total acidity has no meaning for the problem in hand. Only differences are important, and, if in the presence of egg-secretion, a portion of the butyric acid is transformed into butyric ester, the tubes in which this occurs should require less alkali than the controls in order to reach the turning point, P_{H_7}, of di-brom-thymol-sulpho-phthalein.

The differences of acidity actually found between 10 c.c. of control and 10 c.c. of digest, in one case, after 40 minutes at 20° C., amounted to .8 c.c. NaOH N/20; in another, after an hour, to 2.4 c.c. NaOH N/20, in both instances, in favor of the controls.

Absolutely, these discrepancies are small, but even greater differences might fail to be convincing, for conceivably, the organic constituents of the secretion, still largely unknown, might in some way destroy or otherwise remove butyric acid from the reaction system. Fortunately, however, ethyl butyrate has an odor so penetrating and characteristic that even minute traces can be unmistakably detected. By this delicate test, the ester, regularly absent from the controls, was present in noticeable quantities in the digests with secretion and was easily recognized by others not familiar with the experiments. For eighteen hours the ester smell continued to grow in intensity.

On the basis of these results, I attribute to egg-exudate the power to accelerate the synthesis of ethyl butyrate. This is neither more nor less than might be expected since the same exudate also accelerates the corresponding hydrolysis.

OTTO GLASER
AMHERST COLLEGE,
FEBRUARY 2, 1922

1 Woodward: *J. Exp. Zool.*, Vol 26, pp. 459-501.
2 Glaser: *Am. Nat.*, Vol. LV, pp. 368-373.
3 Glaser: *Biol. Bull.*, Vol. XLI, pp. 63-72.
4 Woodward: *Biol. Bull.*, Vol. XLI, pp. 276-279.
5 Glaser: *Biol. Bull.*, Vol. XXVI, pp. 387-409.

NATIONAL ACADEMY OF SCIENCES

At the annual meeting of the National Academy of Sciences held in the U. S. National Museum, Washington, on April 24, 25 and 26, papers were presented as follows:

The new building of the National Academy and the National Research Council: C. D. WALCOTT, President of the Academy. The erection of a magnificent building, costing $1,300,000, as the home of the National Academy of Sciences and the National Research Council, will shortly be begun on the square bounded by B and C streets, 21st and 22d streets, northwest, Washington. The

building will serve as a center for American science in its various fields. Here investigators from all parts of the country and from abroad may be brought togther for counsel and cooperation. Facing the Lincoln Memorial, the marble building in simple classical style will rise three stories from a broad terrace. It has a frontage of 260 feet. On the first floor there will be an auditorium seating some 600 people, a lecture hall holding 250, a reading room, library, conference rooms and exhibition halls. The basement concontains a cafeteria and kitchen. The two upper floors will be devoted to offices. The building is the gift of the Carnegie Corporation of New York, while the ground was bought at a cost of about $200,000 through the donations of about a score of benefactors. Bertram Grosvenor Goodhue of New York is the architect. He is one of the best known architects in the country and designed the St. Thomas Church, the West Point buildings, the Nebraska State Capitol and many other buildings. The contract for the construction of the building has been let to Charles T. Wills, Inc., of New York, and it is expected that the building will be ready for occupancy in the autumn of 1923. Lee Laurie, the sculptor, has been selected to do the decorations, which will symbolize and depict the progress of science and its benefits to humanity. A series of bronze basreliefs will show a procession of the leaders of scientific thought from the earliest Greek philosophers to modern Americans. On passing through the entrance hall the visitor will find himself in a lofty rotunda. Here he will see in actual operation apparatus demonstrating certain fundamental scientific facts that hitherto he has had to take on hearsay. A coelostat telescope, mounted on the dome of the central rotunda, will form a large image of the sun on the white surface of a circular table in the middle of the room. Here visitors will be able to see the sun-spots, changing in number and form from day to day, and moving across the disk as the sun turns on its axis. A 60 foot pendulum, suspended from the center of the dome, will be set swinging through a long arc, repeating the celebrated experiment of Foucault. The swinging pendulum will mark an invariable direction in space, and as the earth and the building rotate beneath it, their rotation will be plainly shown by the steady change in direction of the pendulum's swing over a divided arc. Two great phenomena of nature, the sun and the rotation of the earth, are thus to be exhibited. Other phenomena to be demonstrated in striking form in the central rotunda are magnetic storms, earthquakes, gravitational pull of small masses, the pressure of light, the visible growth of plants, swimming infusoria in a drop of ditch water, living bacteria and other interesting phenomena. In the seven exhibition rooms surrounding the central rotunda the latest results of scientific and industrial research will be illustrated. One room will be set aside for the use of government bureaus, another for industrial research laboratories, others for the laboratories, observatories and research institutes of universities and other institutions. The newest discoveries and advances in the mathematical, physical and biological sciences and their applications will be shown in this living museum, whose exhibits will be constantly changing with the progress of science. One week there may be displayed the latest forms of radio telephony; the next perhaps a set of psychological tests or a new find of fossils or a series of synthetic chemical compounds. Such a mutating museum will continue to attract and instruct large numbers of tourists and residents.

Queries concerning the origin of the Australian floras: PROFESSOR D. H. CAMPBELL, Leland Stanford, Jr., University, California. (1) The conditions in the north and south temperate zones are very different. The boreal floras are relatively uniform, owing to the proximity of the Eurasian and North American continents. The south temperate floras are much less intimately related on account of the extreme isolation of the principal land masses, viz., South America, South Africa and Australia. (2) An early separation of the land masses of the northern and southern hemispheres is indicated by the very great differences between the vegetation of the north and south temperate zones. The most prominent types in each region are either completely absent from the other, or very sparingly represented. The south temperate zone has no oaks, chestnuts, walnuts, poplars, maples and many other deciduous trees and shrubs of the north. On the other hand, the Casuarinas and Proteaceæ (Banksia, Grevillea, etc.), the Eucalypti and other Myrtaceæ, as well as many other evergreen trees and shrubs, are unknown in the northern regions. The same is true of the Conifers. The true pines, firs and spruces of the north are replaced by the Araucarias, Agathis and Podocarpus of the south. (3) Australia presents an extraordinary degree of endemism, especially in western Australia, the headquarters of the autochthonous flora. (4) Australia has three distinct floras—*a.* The tropical rain-forest of the coastal regions of Queensland and New South Wales.

b. The sub-antarctic flora of Tasmania and the alpine regions of New South Wales and Victoria. *c.* The autochthonous flora, practically universally distributed, but especially developed in western Australia. (5) The tropical vegetation of northeastern Australia is evidently closely related to the floras of New Guinea and the Malay Archipelago. (6) The sub-antarctic flora, especially developed in Tasmania and New Zealand, is evidently related to the Fuegian flora of South America. It has been the subject of repeated investigation. (7) The autochthonous flora, which comprises a large majority of the Australian plants, is the main subject of the present discussion. This flora is supposed to have developed in western Australia, when it was completely separated from the eastern part of the continent, and to have later spread over the whole continent. The main problem at hand is to discover evidence which will throw light on the origin of this flora. (8) There are some notable correspondences between the flora of South Africa and Australia indicating some former land connection; but as yet no evidence for this has been found, except at a very early period. (9) Gondwana Land, the great southern continent, believed to have existed at the end of the Paleozoic, is supposed to have united South America, Africa and Australia; but a much later connection between South Africa and Australia must be assumed to explain the resemblances between their present floras, as presumably there were no Angiosperms in existence at the period of the supposed Gondwana continent. What is particularly needed is evidence showing the relation of the land masses of the southern hemisphere during the Cretaceous and the Tertiary. Especially important is a knowledge of the fossil plants of these periods, from temperate South America, South Africa and Australia. (10) It is possible that when the fossil plants from these regions are thoroughly studied it may prove that in the south temperate zone, as in the corresponding northern latitudes, during the Cretaceous and much of the Tertiary a practically uniform flora prevailed. Should such prove to be the case, it is probable that the existing floras in the south temperate regions are the descendants of this uniform flora, which shut off in these completely isolated areas have become altered to a greater or less extent. Western Australia, the most completely isolated of the southern regions, has developed the richest and most specialized flora.

The nature of disease, resistance or immunity in certain plants: PROFESSOR L. R. JONES, J. G. DICKSON and J. C. WALKER, University of Wisconsin.

A side effect from the importation of parasites of injurious insects: DR. L. O. HOWARD, chief of the Bureau of Entomology, Department of Agriculture. In the efforts to bring about a natural biological control of injurious insects in many parts of the world, an increasing amount of work is being done by the entomologists of the different nations to bring into their own countries the foreign parasites of foreign insect pests that have been accidentally introduced and have become established. In the course of this work, the motivating idea is the control of the specific introduced pest; but it has developed in many instances that the introduced parasite is not specific to the introduced host, but attacks allied native injurious species. The speaker described a number of these instances in America. These findings offer a very strong additional argument in favor of the prosecution of work of this character.

Mitochondrial bodies in the spermatogenesis of Chorthippus Curtipennis (Scudd.): DR. E. L. MARK and L. C. WYMAN, Harvard University. Numerous bodies found in the apical (Verson's) cell of the testicular follicle, as well as in the primary and secondary spermatogonia, the first and second spermatocytes, and the spermatides of this grasshopper are described as spheroidal structures composed of two substances, a central nonstainable core and a deeply stainable mantle or cortex. The appearance of the bodies when stained is that of a vesicle with clear contents and stained wall of no great thickness. They occur in a single large cluster, or in smaller groups, and are accompanied by finely granular deeply staining cytoplasmic substance. These vesicle-like bodies are believed to be mitochondria, and are genetically continuous from the primary spermatogonium to the formation of the spermatid. In the metamorphosis of the spermatid into a spermatozoon their history has been traced till they break up into minute granulations enveloping the axial filament of the thread-like mature spermatozoon. At each of the cell divisions of spermatogenesis the vesicles are collected into a ring at the periphery of the equatorial region of the spindle figure, and soon after the chromosomes divide and separate, in the metaphase of cell division to form two daughter nuclei, it is found that these vesicles are likewise arranged in the form of two parallel rings—each containing about the same number of vesicles—one on each side of the

plane of cell division, and that with the constriction of the cytoplasm during the division each ring occupies a position between the nucleus of the daughter cell and the cell plate. This ring becomes condensed into an irregular disk which lies close to the nuclear membrane, where it remains during the interkinetic, or so-called resting, stage. On the approach of cell division, the disk breaks up into clusters of vesicles, varying in number from two or three to a dozen or more, which become distributed irregularly through the cytoplasm, but chiefly in regions peripheral to the spindle figure. During the late prophase and early metaphase of nuclear division, the clusters of vesicles with their enveloping finely granular matter are again collected into an equatorial ring. At the end of the second maturation division, which results in the formation of the spermatid, the vesicles, at first small and numerous, constitute a thick disk-like structure at one pole of the nucleus. By the time the chromatin has resumed the appearance of a fine network, two things have happened in the disk-like group of vesicles, now become spheroidal; by confluence they have increased in size and diminished in number; at the same time a differentiation has taken place in them so that a few small centrally-located ones, probably not resulting from confluence, are deeply stainable, whereas the more peripheral and larger ones have become so distended with non-stainable substance that they appear very pale. The confluence of the peripheral pale vesicles continues till there are only two, which are mutually flattened in a plane passing through the center of the nucleus. Each of the two contains a small number of the small deeply staining vesicles. Meanwhile the cytoplasm on the side of the cell corresponding to the vesicles begins to elongate to form the tail. Then the two vesicles move away from the nucleus a short distance and eaeh becomes spheroidal. Between the two appears the axial filament and as the cytoplasmic outgrowth becomes still more elongated, the two spheroidal structures also become elongated in a direction parallel with the axial filament, which they closely invest. The small contained deeply staining vesicles become arranged in a longitudinal row; the wall of the outer enveloping sac disappears, setting free the deeply staining vesicles, which now become distributed along the axial filament, and finally break down, furnishing the finely granular envelope enclosing the axial filament.

Vegetative types of Datura due to differences in somatic number of chromosomes: DR. A. F. BLAKESLEE, Carnegie Institution of Washington, Cold Spring Harbor, L. I., N. Y. Normal plants have 2 n chromosomes in somatic cells. Certain Datura mutants differ in chromosome number from the norm. Of *balanced* types, with an equal number of chromosomes in each set, forms occur with 1 n, 3 n and 4 n chromosomes. Of *unbalanced* types, with an excess or a deficiency of one or more chromosomes in one or more of the individual sets, forms occur with such somatic formulæ as $(2n + 1)$ and $(4n - 1)$. These differences in chromosome number, especially in unbalanced types, cause distinct differences in somatic structure. Several thousand vegetative forms are considered theoretically possible from chromosomal types already discovered.

A method for the study of filterable viruses as applied to vaccinia: DR. W. G. MACCALLUM and E. H. OPPENHEIMER, of the Johns Hopkins University. Attempts at the isolation of the infective agent in vaccine and smallpox have failed. It can at least be separated from most contaminating material if it be centrifugalized in a suspending fluid of appropriate specific gravity. The infective material in vaccine lymphs rises to the top in a fluid of specific gravity 1.16 and sinks to the bottom in any fluid of specific gravity lower than 1.13.

Continuation report on experiments in epidemiology: DRS. SIMON FLEXNER and H. L. AMOSS, Rockefeller Institute for Medical Research. The continuation report on epidemiology relates first to the epidemic disease, mouse typhoid, reported on at the last spring meeting of the academy, and second to an epidemic disease, rabbit septicemia, which is not infrequently met with among domesticated rabbits and the nature of the spread of which we have undertaken to study under controlled experimental conditions. These two diseases represent also two divergent modes of propagation of epidemics of disease, namely, by way of the gastrointestinal organs as in mouse typhoid, and through the respiratory organs as in rabbit septicemia. The ultimate purpose of the investigation is the securing of precise knowledge which may come to bear on and extend knowledge regarding the manner of spread and its underlying causes of such epidemic diseases in man as meningitis, poliomyelitis, influenza, cholera, etc.

Replantation of entire limbs without suture of vessels: DR. W. S. HALSTED, Johns Hopkins Hospital, Baltimore, Md. The experiments were made in the effort to ascertain the cause of the swelling of the arm after the radical operation for cancer of the breast. This swelling has been

universally attributed to the excision of the lymphatics or lymphatics and veins of the axilla. The author believes that infection is the essential factor. In our experiments a cut was made through all of the tissues of the thigh except the sciatic nerve, femoral artery, femoral vein, and femur. The divided structures were immediately sutured and the wound completely closed. At various periods after the operation the vein and artery were ligated. In one instance two days sufficed, but ordinarily four days were required for the adequate reestablishment of the venous circulation through the scar. The artery can not be safely tied until about the twelfth (?) day. The grafted limb becomes swollen for only a few days after the amputation, and again in some instances for a day or two after ligation of the vein. Lantern slides were shown of the new vessels passing through the scar which alone maintain the life of the leg. An operation for cancer of the breast which eliminates the danger of a swollen arm was briefly described and illustrated.

Recent discoveries on the antiquity of man: DR. H. F. OSBORN and C. A. REED.

Stature and head form in Americans of old families: DR. A. HRDLIČKA. Conditions to be reported upon are a part of the results of a careful study of a large group of adult normal men and women descending from families three to eight generations born American. The stature averages 5 feet 8½ inches in the men and nearly 5 feet 4 inches in the women, which is well above the general mean of this country and is higher than in any large group of whites in Europe. The head is of good size, particularly so in the women. The form of the head, however, shows a great variation, indicating only little tendency so far towards any intermediate, American, type. The type of physiognomy shows a closer approach towards such a type, though similar changes are also observable in the better classes of England.

Animal evolution: DR. AUSTIN H. CLARK, U. S. National Museum.

The distribution of the Motmots of the genus Momotus: DR. FRANK M. CHAPMAN, American Museum of Natural History. The Motmots, a distinctively American family of birds, range from the northern limit of the tropical zone in northeastern Mexico to its southern limit in northern Argentina. The family contains six genera and approximately fifteen species and twenty-one sub-species, of which about one half are included in the genus *Momotus*. Motmots are believed to have originated in Middle America whence they have made at least three invasions into South America, one probably pre-Andean and two post-Andean. The first invasion reached the forested area of southeastern Brazil where the now existing species is separated from its nearest ally by an area 1,000 miles in width in which no member of its genus (*Baryphthengus*) is known. This hiatus in the range of the group was possibly occasioned by the entrance of the sea into the Amazon Valley. The second invasion carried a form into the Andean subtropical zone from Costa Rica, over a Panama subtropical "bridge" which has since subsided, almost to Bolivia. The third invasion, made apparently from Panama, populated northern Colombia, the coastal region of Venezuela, Trinidad and Tobago, which were doubtless at that time attached to the continent. Subsequently the birds doubtless crossed the Andes over the comparatively low Andalucia Pass at the head of the Magdalena Valley, and spread over the greater part of tropical South America. In this area they have become differentiated into nine recognized races which present interesting responses to their environment, including some marked instances of convergence. The extreme forms, occupying different banks of the lower Amazon, have apparently become specifically distinct although they evidently have a common ancestor with which they are still connected.

New results on the theory of the minor planets: PROFESSOR A. O. LEUSCHNER, University of California (by title).

Dark nebulæ: PROFESSOR H. N. RUSSELL, Princeton University (by title).

The larger results of twenty years of solar radiation observations: DR. C. G. ABBOT, Smithsonian Institution, F. E. FOWLE and L. B. ALDRICH. This report gave a summary of twenty years' study of solar radiation. This is one of the most important of the constants of nature, for upon it depends the energy required for all our machinery and our muscular power. If the sun varied as much as the other stars, we should alternately freeze and fry. But Dr. Abbott's examination of all available evidence shows that the sun's heat has not varied more than six per cent. above or below the average in the last twenty years. But whenever a series of spots pass across the surface of the sun the amount of heat and light given off falls from one to five per cent. Any such change in the sun's rays has an effect upon the weather and electrical conditions of the earth. It is therefore

possible to tell what the weather is going to be by watching the sun. The Weather Bureau of Argentina sent out forecasts a week in advance based upon the solar observations telegraphed in daily from the Smithsonian Institution at Montezuma, Chile. From compilation of about 2,000 observations, it has been found that the heat radiated by the sun amounts to 1.94 calories per square centimeter per minute. This would be sufficient to melt a layer of ice 424 feet thick all around the sun. A large number of by-products relating to the temperature of the sun, transparency of the atmosphere, the number of molecules per cubic centimeter in the atmosphere, the brightness of the sky, the cooling of the earth by long-wave rays, the distribution of brightness over the sun's disk, and the general theory of the nature of the sun have come out of the investigations.

Problems of modern physics: DR. H. A. LORENTZ, University of Leyden. The lecture passed in review some problems of prominent interest. Foremost among them are the quantum theory, the problems of atomic structure and of gravitation. All these are awaiting their solution and much remains also to be done before it will be possible to explain the properties of magnetic substances, to account for terrestrial and solar magnetism and to understand the more complicated forms of the Zeeman effect. The motion of electricity in metals and effects connected with it likewise require laborious investigation. Here much may be expected of low temperature research.

Researches on thiazoles: DR. MARSTON TAYLOR BOGERT, Columbia University. In the benzothiazole group, various new derivatives have been prepared and studied, several of which are interesting because of therapeutic or tinctorial possibilities.

Researches on selenium organic compounds: DR. MARSTON TAYLOR BOGERT. New selenium organic compounds have been synthesized and studied in the quinazolone and benzelenasole groups, the azo dyes from the latter being much deeper in shade than the corresponding sulfur compounds.

Reaction between silver perchlorate and the halogens: PROFESSOR M. GOMBERG, University of Michigan. A study of the reaction indicated in the title has been undertaken in order to prepare, if possible, the compound radical (ClO_4):

$$2AgClO_4 + I_2 = 2AgI + 2(ClO_4).$$

If found to exist as monomolecular it should, it was thought, be either identical or isomeric with the ion of the same composition; if dimolecular, $(ClO_4)_2$, it should prove a higher oxide of chlorine than any hitherto known. Numerous experiments were carried out during the last year, with the halogens chlorine, bromine and iodine, and with solvents chosen from a wide range of compounds. Iodine and ether were finally adopted as best suited for this reaction, because of the formation of less by-products. At this stage of the investigation it may be considered as having been fairly well established that $(ClO_4)_x$ actually does exist, but its molecular state has not yet been determined. The compound has been prepared only in solutions of one per cent. to five per cent., and has been found to be practically non-volatile with vapors of ether at 30° C. and 100 mm. pressure. It is a powerfully reactive substance. It reacts with the oxides of various metals; it attacks zinc, magnesium, copper, silver, iron, tin, and other metals with the formation of the corresponding perchlorates; with water it gives perchloric acid, and it liberates iodine from hydriodic acid. The investigation is to be continued.

The thermal decomposition of tungsten: DR. GERALD L. WENDT.

A confirmation of Saha's theory of the ionization of the elements at high temperature: DRS. ARTHUR A. NOYES and H. A. WILSON, California Institute of Technology. By employing the usual thermodynamic expression for the change of chemical equilibrium with the temperature, and supplementing this by an evaluation, based on fairly well established theoretical considerations, of the specific constants occurring in that expression, Saha (*Phil. Mag.*, 40: 479, 1920) has shown that one can compute from the ionization-potential of an element the extent to which its neutral atoms are converted into ions at any temperature or pressure; for example, the extent to which sodium undergoes the reaction $Na = Na^+ + e$, where e denotes the electron. This computation has proved of great astronomical interest because of the new possibilities it affords of interpreting the presence, absence, or relative intensities of the spectra of certain elements under different stellar conditions. The fact, however, that Saha's computations involve certain hypotheses makes the experimental confirmation of his conclusions highly desirable; and it is the purpose of the authors' paper to show that the experiments of one of them (H. A. Wilson) on the electrical conductivity of flames furnish such a confirmation.

The general system of isotopes as related to the formation and disintegration of atom nuclei:

PROFESSOR WILLIAM D. HARKINS, University of Chicago. The nucleus of any complex atom may be considered as a highly condensed proton-electron aggregate. Up to the present none of these condensed aggregates have been found to be electrically neutral (neutrons), and in *most* atoms which exist on earth and in the meteorites each electron binds two protons. Thus the composition of the nuclei of most atoms may be expressed by the formula $(p_2e)_M$, in which p represents a positive electron (proton), e an electron, and M is the atomic number. No atomic species has been discovered in which one electron binds more than two protons. The simplest complex nucleus is that of the helium atom (the alpha particle) which has the formula $(p_2e)_2$ This is also the most abundant group present in more complex nuclei. It was shown by Harkins and Wilson in 1915 that according to the special relativity theory the amount of energy liberated in the formation of four grams of helium from protons and electrons, that is, from hydrogen, is 6.7×10^{11} calories, or five million times the energy liberated when the same weight of hydrogen unites with oxygen to form water. This is about three fifths of the energy which would be liberated in the complete change of 238 grams of uranium into 206 grams of lead, 32 grams of alpha particles, —6N electrons (where N represents the avogadro number) and about 0.05 grams of radiant energy. The energy which would be liberated in the formation of alpha particles from hydrogen is so great that it would seem that this reaction should proceed at an extremely high speed. That this is not the case may be due to the fact that for some unknown reason one electron does not form a very stable union with one proton, but the common ratio is two of the latter to one of the former in the most stable aggregates. Thus it is not improbable that four protons and two electrons seldom meet at one time in such relative positions as to allow the alpha particle to be formed. It may be suggested that the first step in the building of an alpha particle may be the formation of the aggregate p_2e, which is stable with reference to aggregation, but easily unites with a like particle to form the group $(p_2e)_2$, or the alpha particle. According to Rutherford's hypothesis the carbon nucleus consists of four groups of the formula p_3e. While the evidence in favor of this assumption is not specially convincing, there is on the other hand no evidence against it. However, definite evidence will be presented which proves that the alpha particle is the principal group concerned in the growth of carbon nuclei into those which are heavier. The composition of any complex nucleus may be expressed by the formula $(p_2e)_M(pe)_n$, in which n represents the *isotopic number*. This number varies from 0 to 54 for known atomic species, and is 0 for most atoms. In the range in which the isotopic number is small, the most abundant species of atoms are those whose isotopic numbers are divisible by 4, while for higher isotopic numbers the maxima of abundance are not so distinct, and occur in general for the isotopic numbers which are even. The most important relations which should be taken into consideration in showing the nature of the general system of isotopes are: (1) The number of negative electrons in most atom nuclei is *even*, so in general the atomic weight and the isotopic number are both even when the atomic number is even, and are both odd when the atomic number is odd. (2) As the atomic number increases the isotopic number of the more stable isotopes of an element also increases. This may be expressed as follows: As the *net* positive charge on an atom nucleus increases the atom becomes more unstable unless at the same time the nucleus becomes more negative with reference to its *relative* content of negative electrons. (3) For any set of isotopes the atoms become more unstable with reference to a beta disintegration as the isotopic number increases, and more unstable with reference to an alpha particle disintegration as the isotopic number decreases. This relation does not specify what form of disintegration will take place in any special case, since this probably depends upon the grouping, but it does give the relative rate for any disintegration which actually does take place. Obviously this relation has been tested only in the case of the radioactive elements. The relations which exist in the general system of isotopes will be presented in the form of an extensive plot which exhibits a large number of relations, many of them periodic, which can not be well treated in an abstract.

A theory of electric conduction in metals: PROFESSOR EDWIN H. HALL.

Cooperative studies of California earth movements: DR. ARTHUR L. DAY, director of the Geophysical Laboratory, Carnegie Institution of Washington. Recent information from astronomical sources has indicated a northward crustal movement of small magnitude in northern California. The suggestion has been made that the accumulated strains produced by such movement eventually produce rupture and an elastic recoil

or earthquake. Cooperative studies have been undertaken by the Carnegie Institution of Washington, U. S. Coast and Geodetic Survey, U. S. Geological Survey, the geological departments of the universities of California, the California Institute of Technology, and the Bureau of Standards, with the purpose of gathering precise data bearing upon this subject. It is a part of the program not only to locate the surface displacements either gradual or disruptive, but also to develop instruments and establish stations for the location of sub-surface zones of movement.

Geological overthrusts and underdrags: PROFESSOR W. M. DAVIS, Harvard University (by title). Overthrust masses of earth crust have been found, the front of which has advanced a score of miles or more beyond its original position. On tracing such masses backward, no indications of a cavity left by their advance have been found; hence it may be possible that they have obliquely emerged from beneath rear portions of the crust which have not taken part in their movement. If so, the rear portions should exhibit displacements due to what may be called the "underdrag" of the obliquely emerging masses. Such displacements would be characterized by an increase in horizontal dimensions in the direction of underdrag, and manifested by normal faults on moderately slanting fault planes. The mountain ranges of the Great Basin of Utah and Nevada appear to exhibit such displacements.

The effects of winds and barometric pressures on the Great Lakes: DR. J. F. HAYFORD, Northwestern University. The surface of the water of any one of the Great Lakes is never level except by accident. It always has a slope in some direction, produced by the wind, by barometric pressures, or by the water of the lake oscillating as if it were in a great wash-basin. The correct knowledge of these things is a key to various scientific problems and ultimately will prove to be worth millions, in their application, to the people of the United States. It has long been known that a wind blowing over a lake tends to pile up the water on the lee shore and to pull it down on the windward shore. How large is this effect? Is the response of the water to the wind immediate? It has not been possible to answer these questions confidently in the past. Now it is known that the response is prompt and that the effect of a given wind in disturbing the water level at any point in the world may be computed in advance. It is known that the strongest winds that blow have almost no effect in changing the water level at various points, as, for example, at Milwaukee on Lake Michigan and Mackinaw City on Lake Huron. On the other hand, it is known that a wind of 50 miles per hour from the southwest piles up the water a foot at Buffalo and pulls it down simultaneously more than a foot at the west end of Lake Erie. The reason for this extreme contrast between different places and for the fact that the wind effect is greatest in long shallow bays is now accurately known. The lake surface is also continually tilting up, first in one direction, then in another, in response to varying barometric pressures. The water tends to go toward a region of low barometric pressure and pile up there. Such effects at Mackinaw City and Milwaukee frequently amount to three inches or more, although wind effects at these points are almost inappreciable. Just as a piano string struck once, or the air in an organ pipe continuously agitated by a reed, vibrates with its natural period, so the water of each of the Great Lakes under the many impulses given it by the winds and barometric pressures oscillates back and forth. Sometimes the whole of a lake is concerned in an oscillation, and sometimes the lake oscillates in parts. Such oscillations in lakes are called seiches.

Striking similarities between the igneous rocks of Brazil and South Africa: DR. H. A. BROUWER. Striking similarities in geological age and in composition exist between the old granites and gneisses with intrusive younger granites, the precretaceous intrusive sheets of diabase, the lava flows of the Serra Geral and the Drakensberg, the pipes and dykes of kimberlite and the intrusive and effusive alkali rocks (nephelinesyenites, phonolites, etc.). The alkali rocks are found on both sides of the Atlantic Ocean near the coast; they form denuded volcanic centers and if the west coast of Africa and the east coast of South America be considered in juxtaposition the location of these older volcanoes would be very similar to that of the young volcanoes of alkali rocks (Kenia, etc.) near the young fracture-system, bordering the rift valleys in East Africa. Very long dykes of nephelinesyenites prove the existence of similar fractures in the central part of South Africa.

Fauna of the Pleistocene asphalt deposits of McKittrick, California: DR. JOHN C. MERRIAM, president of the Carnegie Institution of Washington, and CHESTER STOCK, University of California. The discovery of an enormous accumulation of perfectly preserved remains of extinct animals found in asphalt beds in the environs of Los

Angeles, California, some years ago furnished some of the most interesting data on the history of life thus far secured in America. A similar deposit representing an assemblage of animals of a somewhat different type has recently been opened for extensive investigation on the western border of the Great Valley of California. Remains of a wide variety of higher animals and birds were found at this new locality. The collection represents the geological period immediately preceding the present and offers the best opportunity thus far known to study the life of this late geological stage under the conditions obtaining in the Great Valley of California.

The telephone engineer a public trustee: FRANK B. JEWETT, vice-president, Western Electric Company. In his paper, which was a statement of the unique position which the telephone engineer of to-day occupies in relation to the general public, Dr. Jewett outlined the organization of the communication service of the United States and pointed out the position and scope of work of the engineer in this organization. Dr. Jewett indicated that the telephone art, even at the end of nearly half a century of the most intensive development and monumental growth, was still far from being an agency requiring little or no change. He showed that the recent developments in physical science had opened up vast possibilities of new and improved communication services which the telephone engineer was endeavoring to make available for public service, and indicated some of the problems which were being successfully attacked. He also pictured some of the tremendous difficulties which confronted the telephone engineer in incorporating these new services into the existing structure, which was itself growing rapidly along already developed lines, without producing disruptions of service. Finally he pointed out that the telephone engineer of to-day had come to recognize that his function was in effect that of a public trustee and that his problem was not alone that of developing new and improved instrumentalities, but of developing these instrumentalities and making them available to the public without subjecting the telephone user to annoyance as a result of experimentation on the public at large.

The loud speaking telephone: FRANK B. JEWETT, vice-president, Western Electric Company. For many years, and in fact almost from Dr. Bell's discovery that human speech could be transmitted to distant points electrically, there has been incessant quest for a satisfactory loud speaking telephone. Innumerable attempts to devise instruments of this kind have been made in the last thirty or forty years and until recently all have been substantial failures. Recently, however, really successful instrumentalities have been produced and the field of possible influence on all social and human relations which has opened up was evidenced graphically in the Armstice Day exercises attendant upon the burial of the Unknown Soldier at Arlington, Virginia. In these ceremonies vast audiences in San Francisco, New York and Washington listened to the President of the United States and other speakers and joined in common exercises of respect to America's dead. Dr. Jewett's paper, which was illustrated by a local demonstration and by a demonstration of talking over the regular telephone wires from New York, described the physical and electrical problems whose solution had to be achieved in order to make the loud speaking telephone a success. He pointed out that the problem consisted essentially of four main elements, namely: (1) The development of telephone transmitters capable of picking up the sound vibrations of the speaker's voice when the latter was speaking normally at some distance from the instrument, and of faithfully translating these vibrations into electrical vibrations for transmission over the wires; (2) the transmission of these electrical vibrations undistorted to the distant point; (3) the amplification at the distant point of the received electrical impulses to an energy value many times greater than that produced by the transmitter at the speaker's end of the line; and (4) the translation back into sound vibrations of these greatly amplified speech waves through an appropriate loud speaking receiver. He pointed out that if the received speech through the loud speaking receivers was to be of acceptable quality no serious distortion could take place in any of the links of the chain from the speaker to his distant audience, and that the inherent characteristics of the loud-speaking system call for even more faithful reproduction than is necessary in ordinary telephones of recognized good quality. He pointed out further that because of the necessity of using ordinary telephone lines, which in most cases were in close proximity to numerous other telephone lines used in the regular way, it was necessary that the currents transmitted from one end of the line to the other should be substantially of the same magnitude as those produced in the use of the ordinary telephone. He showed that this requirement, combined with the necessarily inefficient energy characteristics of the originating transmitter and the tremendous energy

requirements of the loud speaking telephones had made the problem inherently insoluble until means had been developed for producing telephone lines with very uniform transmitting characteristics and until amplifying devices of great power, uniformity and freedom from inherent distortion production had been developed.

The physical examination of hearing and binaural aids for the deaf: R. L. WEGEL, Western Electric Company, New York City. The function of the auditory sense is to detect sounds of different wave shapes, the ratio of the pressure on the ear drum varying over a range of 1 : 1,000,000. It must also differentiate between sounds so nearly alike that no existing physical apparatus is capable of separating them. Binaural audition adds a sense of orientation and discrimination together with a more uniform sensitivity for sounds approaching from different directions. A binaural set for aiding the hard-of-hearing was exhibited. An abnormal auditory sense may be regarded as one lacking to a greater or less degree in (1) range of sensation (frequency or intensity), (2) quality of sensation in various regions of the range, (3) binaural sense. Methods have been studied for exploring the outstanding elements of these functions. A new audiometer for measurement of hearing was shown.

The relative sensitivity of the ear at different levels of loudness: DR. DONALD MACKENZIE, Western Electric Company. Up to the present time there has been no satisfactory technique for loudness comparisons of different tones. In this paper a description is given of an alternation phonometer which makes it an easy matter to adjust to equal loudness two tones of different pitches. With this instrument a determination has been made of the relative sensitivity of normal ears of both men and women, over the pitch range from bass G to C5, at sound intensities midway between the faintest audible and the painfully loud. It is found that the sound energy necessary to produce a given loudness is smaller the higher the pitch, at least within the range examined. Different ears agree more closely at these intensities than at the least audible, and no difference is detectible between men and women. Interpretation of the results shows them to be in harmony with Fechner's law, according to which the difference between the sensations due to two lights of the same color or two tones of the same pitch is proportional to the ratio of intensities of the lights or sounds causing the sensations. This simple law holds only at moderate intensities. Phonometric comparisons by a small number of observers were made at intensities from very faint to very loud. It appears that any one ear varies from day to day, but these variations are most noticeable at the extremes of loudness. The results taken all together strongly suggest that, on the average, the relative sensitivity of the ear to different musical notes is practically the same whether the sounds are loud or faint.

Recent progress in aeronautics: PROFESSOR J. S. AMES, The Johns Hopkins University.

Coefficients of slip and the reflection of molecules: DR. R. A. MILLIKAN, Norman Bridge Laboratory of Physics, Pasadena. This paper contains a presentation of the theoretical relations between the coefficient of slip and the law of reflection of gas molecules from the surfaces of solids and liquids. It presents, also new experimental data taken by the author and his pupils which completely check the correctness of this theory. It gives for the first time the exact ratio between the number of impinging molecules which are specularly reflected in the case of a given gas from given liquid and solid surfaces, and the number which are diffusely reflected. The most interesting facts brought to light by the investigation are, first, that this ratio is different for different kinds of molecules when the nature of the surface remains constant, and, second, that there is a larger coefficient of slip between oiled surfaces and gases than between the same gases and ordinary unoiled surfaces of metal or glass.

Origin of penetrating radiations of the upper air: DR. R. A. MILLIKAN, Norman Bridge Laboratory of Physics, Pasadena. It is of intense interest to know whether the penetrating radiations which have been heretofore studied up to altitudes of 9,000 meters are of cosmic or of terrestrial origin. Pre-war observations made in manned balloons in Germany gave indications that they were of cosmic origin. Observations published last year from the University of California were in opposition to this view. Indeed, the California observers attributed the increase in the rate of discharge of the electroscopes with increasing height, as found in Germany, to the effects of temperature upon the electrical conductivity of the supports of the gold leaves in the electroscopes. The observers at the California Institute of Technology have definitely proved that the temperature effects upon the supports when the experiments are properly performed are practically negligible. They are now making balloon flights in which self-recording instruments are sent up to the very top of the atmosphere, that is, to a point at which only one sixteenth of the atmosphere is

still above, and should be able to determine with certainty by these experiments whether the penetrating rays are of cosmic or of terrestrial origin. While the instruments sent up weigh but 175 grams (6 ounces) they are capable of bringing back a complete record of the temperatures, the pressure, and the penetrating radiations existing at all of the altitudes which they reach. These altitudes should be about three times as great as those ever obtained before in experiments of this kind. These balloon flights will be reported later.

On the measurement of a physical quantity whose magnitude is influenced at random by primary causes beyond the control of the observer, and on the method of determining the relation between two such quantities: DR. WALTER A. SHEWHART, New York City. The objects of scientific investigation are twofold, *i. e.*, the determination of some form of average value and its probable variation, and the determination of the relation existing between two or more such quantities. In many problems of physical and engineering science it is possible to assume that causes of variation of the variable under consideration may be controlled by the observer. Certain problems in these sciences as in the fields of economics and biology arise, however, wherein it is impossible to control the causes of variation, and they must be submitted to a statistical method of solution. An outline of the necessary analysis is given and illustrated. Application of the theory of correlation and its physical interpretation was discussed.

Ether-drift experiments at Mount Wilson in 1921 and at Cleveland in 1922: PROFESSOR DAYTON C. MILLER, Case School of Applied Sciences, Cleveland, Ohio. The Michelson-Morley experiment to detect the relative motion of the earth and ether was performed at Cleveland in 1887. In explanation of the null result then obtained, the Lorentz-FitzGerald effect was proposed. The experiment was repeated by Morley and Miller in 1904, with a much larger and more sensitive apparatus, which was also especially arranged to make a direct test of the Lorentz-FitzGerald effect. Again a null result was obtained. The suggestion was then made that the earth drags the ether, and while there is no "drift" at the surface of the earth, it might be perceptible at an elevation above the general surface. The experiment was again performed by the present author, at the Mount Wilson Solar Observatory in March and April, 1921, where the elevation is nearly 6,000 feet. The results indicated an effect such as would be produced by a true ether-drift, of about one tenth of the expected amount, but there was also present a periodic effect of half the frequency which could not be explained. The interferometer had been mounted on a steel base and in order to eliminate the possibility of magnetic disturbance, a new apparatus with a concrete base and with aluminum supports for the mirrors was constructed. Observations were made in November and December, 1921, the results being substantially the same as in April. Before any conclusions can be drawn, it is necessary to determine the cause of the unexplained disturbance. The interferometer has again been mounted at Case School of Applied Science, in Cleveland, and observations are now in progress, the results of which were reported in this paper, which was illustrated by lantern slides and motion-pictures. About 700 feet of motion-picture film was taken at Mount Wilson by a member of the observatory staff, showing the location and construction of the apparatus and also the method of making the observations.

Some extensions in the mathematics of hydromechanics: DR. R. S. WOODWARD, Washington, D. C. The most general specification of fluid motion requires a minimum of twenty symbols, or factors. Of these the most important are the three velocity components, the three spin components, and the four potentials from which the velocity components are derived by differentiation. *The first part* of the paper shows how it is more advantageous, in general, to make use of the relations between the Laplacians, or the Laplacians of the Laplacians, of these factors, than it is to make use of the relations of a lower order. It is shown that this extension greatly systematizes and simplifies the statement and the solution of problems on the motion of viscous fluids. *The second part* of the paper refers to what the author has ventured to call preharmonics, which are the triple integrals of harmonic functions which figure extensively in hydromechanics. It is shown how to find all of the preharmonics corresponding to all of the harmonic functions of positive and negative integral degrees.

Normal coordinates and Einstein space: G. D. BIRKHOFF.

Algebraic solutions of Einstein's cosmological equations: EDWARD KASNER.

The geometry of paths: OSWALD VEBLEN.

Biographical memoir of Dr. J. A. Allen: F. M. CHAPMAN.

Biographical memoir of Benjamin Apthorp Gould: G. C. COMSTOCK.

Biographical memoir of Henry Pickering Bowditch: W. B. CANNON.