SCIENCE

VOL. 93 FRIDAY, MAY 9, 1941 No. 2419

SCIENCE: A Weekly Journal devoted to the Advancement of Science, edited by J. MCKEEN CATTELL and published every Friday by

THE SCIENCE PRESS

Lancaster, Pa. Garrison, N. Y.

New York City: Grand Central Terminal

Annual Subscription, $6.00 Single Copies, 15 Cts.

SCIENCE is the official organ of the American Association for the Advancement of Science. Information regarding membership in the Association may be secured from the office of the permanent secretary in the Smithsonian Institution Building, Washington, D. C.

THE NATIONAL ACADEMY OF SCIENCES

ABSTRACTS OF PAPERS PRESENTED AT THE ANNUAL MEETING[1]

A hypothesis as to the origin of cosmic rays and the experimental testing of it in India and elsewhere (evening lecture): R. A. MILLIKAN, H. V. NEHER and W. H. PICKERING. The hypothesis here adopted as to the mode of origin of the cosmic rays makes possible the prediction of five definite cosmic-ray bands, each of which should reach the earth in a particular latitude, and of four plateaus of unchanging cosmic-ray intensity, these plateaus being delimited by the latitudes of entrance of the successive bands. The hypothesis rendering possible these predictions rests upon five major discoveries made by the workers in the Norman Bridge Laboratory of Physics at the California Institute of Technology at Pasadena. These discoveries are (1) that more than 60 per cent. of all incoming cosmic-ray energy is of the nature of *electron bullets* each of energy between 2 billion electron-volts and 15 billion electron-volts; (2) Neddermeyer and Anderson's discovery of the production by nuclear impacts within the atmosphere of mesotrons which carry the energy farther down than incoming electrons alone could do; (3) Bowen's two remarkable discoveries: first, that atoms, when out in interstellar space, are able to undergo atomic transformations forbidden to them within the stars, and second, (4) that in ring-nebulae, trillions of miles away from the exciting star and therefore presumably reflecting conditions in interstellar space there are five of the atoms, namely, helium, carbon, nitrogen, oxygen and silicon, each of which is more than ten times more abundant than any other atom save hydrogen (which must be excluded from measurable cosmic-ray effects because of the smallness of its rest-mass energy), and (5) Lauritsen and Fowler's discovery in the Kellogg Radiation Laboratory that a part at least of the rest-mass energy of an atom has the power under suitable conditions of transforming itself directly into the creation of an "electron-pair." The hypothesis made in view of these five discoveries is that, while the evolution of energy by the stars is maintained, as Bethe has recently shown, by the *partial* transformation, within the stars of the rest-mass energy of hydrogen into radiant energy through

[1] Held in the building of the National Academy of Sciences, Washington, April 28 and 29.

the building of helium, carbon and other atoms out of hydrogen, and the release through this process of the so-called "packing-fraction" energy, the energy of cosmic rays on the other hand is maintained, by the occasional *complete* transformation in interstellar space of the rest-mass energy of the atoms of helium, carbon, nitrogen, oxygen and silicon (and even heavier aggregates), into cosmic rays, each such event presumably creating an electron pair, though an occasional photon pair, or neutron pair, or even proton pair for sufficiently high energies, need not *necessarily* be excluded. The foregoing hypothesis requires that the cosmic rays of measurable energy reveal a spectral distribution of five distinct, definitely measurable bands as follows: (1) a band of rays each having an energy of 1.9 billion electron-volts produced by the annihilation, or complete transformation, in interstellar space of the rest-mass energy of the helium atom; (2) a carbon-atom-annihilation band of energy 5.6 billion electron-volts (b.e.v.); (3) a nitrogen atom band of energy 6.6 b.e.v.; (4) an oxygen atom band of energy 7.5 b.e.v. and (5) a silicon atom band of energy 13.2 b.e.v. The hypothesis requires further that there should be in India, for vertically incoming rays, between the magnetic equator and magnetic latitude about 20 degrees N. a plateau of unchanging cosmic-ray intensity with latitude; it requires another such plateau between the latitudes of entrance and the bands due to the silicon and oxygen atoms; it requires a third such plateau between the great band produced by the annihilation of the carbon, nitrogen and oxygen atoms, and that due to the annihilation of helium; and finally it requires a fourth such plateau north of Bismarck, North Dakota, where as the observer goes northward the helium band should first be able to get vertically through the blocking effect of the earth's magnetic field and should then be able to enter the earth in full strength at all more northerly latitudes. The experimental evidence that has been so far obtained in India and elsewhere for the existence of these five bands and four plateaus may be thus summarized. The evidence seems to be excellent for the existence of the silicon band, the joint nitrogen-oxygen band, the carbon band and the helium band. Also all of these bands are found, roughly at least, in the predicted latitudes and of right order of intensities. The evidence also appears to be good for the existence of the four above mentioned plateaus of constant cosmic-ray intensity. Further experiments are being made to see whether better designed apparatus will render the nature of the evidence better or worse for the hypothesis and new experiments in Mexico and the United States are planned for the coming summer. This comparison of prediction and experiment has been made possible largely through the generous support of the investigation by the Carnegie Corporation of New York and the Carnegie Institution of Washington. The success of the work in India was made possible by the extraordinarily generous and complete cooperation of the British Indian Meteorological Service.

Transformations of isothermal families: EDWARD KASNER.

Distribution of mass in the spiral nebulae Messier 31 and 33: A. B. WYSE and N. U. MAYALL (introduced by W. H. Wright). Recent spectroscopic observations of Messier 31 and 33, by one of the authors and his associates, have established the general character of their rotational motions. So far as is known, no other objects of the kind have been sufficiently investigated to yield data competent to indicate the mass distribution. The observational results proved surprising in two respects: first, there is a minimum of rotational velocity, for Messier 31 at least, at a relatively short distance from the center, beyond which there is again an increase; second, the velocities in both nebulae increase outwards to unexpectedly large distances from the center. The results are so little in accord with earlier conceptions of dynamical conditions in the spiral nebulae that it has seemed worth while to inquire whether the observed velocities could be explained on the basis of some hypothetical distribution of material in the two systems. In an attempt to reduce the inquiry to the simplest practicable terms, the mathematical relation between mass distribution and rotational motion has been investigated for non-homogeneous thin disks. Applications to Messier 31 and 33 yield mass distributions that account satisfactorily for the observed velocities of rotation. The results for both spirals indicate only a very slight tendency for the mass to be concentrated toward the center. The high central condensation of mass hitherto commonly ascribed to the Galaxy has been examined, and has been found to be not a necessary consequence of observations of galactic rotation. Comparison of the densities and the rotational velocities in the two spirals with those in the solar neighborhood suggests that the sun may be situated in the outermost parts of the Galaxy, well beyond the main body of the system.

Direction of rotation of spiral nebulae: EDWIN HUBBLE and NICHOLAS U. MAYALL. The paper presents the first unambiguous determination of the direction of rotation of a spiral nebula. The nebula, NGC 3190, an early type, normal spiral, trails its arms as it rotates. The direction of rotation has been an unsolved problem of fundamental importance for theories of the origin and development of spiral structure. The solution involves the determination of the spectrographic rotation of nebulae in which the direction of the spiral patterns can be detected and, at the same time, the sense of the tilt is known (near sides can be distinguished from the far sides). A survey of the 1,000 brightest nebulae in the northern sky has furnished only one system, NGC 3190, which fulfils the last two requirements. The sense of the spectrographic rotation in this nebula has now been observed, and it is found that the spiral trails its arms. In five other spirals, for which spectrographic rotations are available, the direction of rotation is correlated with asymmetry of obscuration. If the sharper and heavier absorption features indicate the near sides, these spirals trail their arms—and *vice versa*. The unambiguous result for NGC 3190 is believed to interpret the correlation, and consequently, suggests that all spirals trail their arms as they rotate.

A Solar Prominence in Three Dimensions: ROBERT R. MCMATH (introduced by Heber D. Curtis). On our solar motion picture films we measure the successive images of formations in solar prominences in two directions at

right angles. The plane in which these projected motions are measured is perpendicular to the line of sight from us to the sun and is called the XY plane. These results are not sufficient to determine the actual motion and speed of a prominence detail in space; for such a purpose we need measures of distances and speeds in three dimensions. The new Stone spectroheliograph of the McMath-Hulbert Observatory gives us the concurrent speeds at which a formation is moving directly toward to directly away from us; that is, a radial velocity, or Z speed, in our line of sight. Armed with measures of distances and speeds in three mutually perpendicular directions, we are able to determine the actual movement in space and the velocity of that motion. A study of the space motions of six knots which traversed fairly persistent streamer paths forms the observational basis of this preliminary paper. The prominence in which the knots were located was under observation for several consecutive days, and a disk spectroheliogram of the prominence and an accompanying sunspot was secured after the spot and prominence had rotated into the field of view. This combination of events enabled us to build a model, based on the observationl data combined with some judgment, which is considered to be a fair representation of the actual space form of the prominence and its streamers. Portions of several of the motions found resemble free fall in a partially compensated gravitational field. These new space motions show clearly that the velocities in the knots included in this investigation are not uniform, and that they are subjected to acceleration or deceleration, depending upon the distribution of the several forces acting in their respective force fields.

Design and characteristics of a magnet for cosmic-ray cloud-chamber studies: ROBERT B. BRODE (introduced by J. A. Fleming). The study of cosmic-ray mesotrons requires a magnet that will appreciably deflect particles of an energy of 10^{10} electron-volts. The operation of a Wilson cloud-chamber requires long periods of operation at constant temperature. The design and dimensions of a magnet for this purpose were determined by studies on small models. In the final magnet 5,300 pounds of steel were used in casting the yokes and 2,700 pounds of copper wire were used in the coils. To reduce the saturation in the steel, the poles were coned from a diameter of 18 inches to a diameter of 12 inches in ten inches distance. The front pole has a conical hole in it that permits the cloud-chamber to be photographed directly without the use of mirrors. The hollow center of the front pole throws flux from the center towards the outside so that the flux-density as measured in the illuminated plane of a cloud-chamber 30 cm in diameter is constant to within 5 per cent. The coils were wound with No. 6 square double-glass-covered copper wire. The turns were cemented together with an air-drying binder. Cooling is provided by the circulation of water in four layers of copper tubing in each coil. Six kilowatts obtained from the direct-current supply system produced an average field of over 9,000 gauss. In spite of the large hole in the front pole the equivalent air-gap of the magnet is only 14 cm.

Studies of mesotron absorption and production in a large Wilson chamber: T. H. JOHNSON (introduced by F. E. Wright). Studies bearing upon the production and disappearance of mesotrons have been made by R. P. Shutt and the writer in a large Wilson chamber containing three lead plates. Since the observational data consist of the directions and the densities of the tracks before and after the traversals, whereas the processes of interest occur within the lead plates and are not observed directly, the method is essentially statistical. A pair of mesons, originating in a lead plate with no visible particle entering above, would be evidence of the production of mesons by gamma rays, but no events of this nature have been observed, although we would have expected many if the hypothesis were tenable that gamma rays in the upper atmosphere are the principal producers of mesons. The ratio of the number of slow mesons with dense tracks in the gas to the number stopped by the lead plates agrees with expectations based upon the ionization losses and gives no indication of other absorptive processes. The scattering of the mesons by the lead is also that predicted for the coulomb forces and gives no indication of extraordinary forces acting between mesons and lead nuclei. If mesons are being stopped by processes other than ionization, the statistics obtained from 10,000 tracks traversing the lead are insufficient to put such processes in evidence, and it will be necessary to adopt a technique in which the individual events are observed directly in a dense gas. For this purpose we are constructing a cloud chamber 12 inches in diameter to operate at a pressure of 200 to 300 atmospheres. This chamber will be immersed in a transparent oil contained in a thick-walled steel tank. Photographs will be made through a thick glass window the size of the camera lens, and the chamber will be illuminated by arcs placed inside the tank. When filled with argon this chamber will have a cosmic-ray stopping power equivalent to 7 cms of water or nearly 1 cm of lead.

Diffraction gratings and replicas far astrophysical research: R. W. WOOD. An account was given of improvements made in the construction of large reflecting gratings ruled on an aluminum surface which have resulted in their adoption in place of prisms in the large spectrograph of the 100-inch telescope at Mt. Wilson and elsewhere. A report of the excellent results obtained with these gratings, by Dr. Adams, the director of the observatory, appears in the January number of the *Astrophysical Journal.* Great advances have also been made in the preparation of large transparent diffraction gratings (replicas) for astrophysical research. Six replica gratings, each measuring 4 x 6¼ inches, with 800 lines to the inch, throwing about 90 per cent. of the light into the first order spectrum, were made and mounted between thin glass plates figured by Taylor Bethel, of Southport, Long Island. These were mounted in adjustable aluminum frames over the 18-inch Schmidt star camera at Mt. Palomar by Dr. Zwicky, and excellent results obtained. Nine absorption lines of the hydrogen series appeared in the spectrum of Sirius made with a very short exposure. No spectra of

higher order appeared, and the central image was a faint narrow line. These gratings covered only 60 per cent. of the aperture of the Schmidt. Two glass discs 18 inches in diameter are now in preparation, and similar replicas will be mounted between them, covering 98 per cent. of the camera's aperture. Dr. Zwicky is of the opinion that a wide field of investigation on the classification of the spectra of very faint stars will open up by the use of this arrangement. The replicas have high dispersion and give great intensity in the infra red, the calcium line at 8,542 coming out strong. Last year, with a replica of 7,500 lines to the inch mounted over a 3-inch Schmidt camera of only 5 inches focus, at the Mt. Wilson, I obtained an excellent spectrum of Arcturus in 15 seconds and one of the ring nebula in Lyra in 10 minutes. A new combination was described for determining the velocities of faint stars. Two replica gratings are mounted on two prisms, so oriented as to yield two spectra of each star in coincidence one above the other but facing in opposite directions, the violet portions being side by side. The spectra are pushed together or pulled apart according as the star is approaching or receding, and the velocity determined by the shift of the lines. This has been tested at the Harvard Observatory with good results.

Protons as primary cosmic rays: ARTHUR H. COMPTON and MARCEL SCHEIN. Starting with the hypothesis that the primary cosmic ray particles entering the atmosphere consist solely of protons, the consequences are compared with the major cosmic ray phenomena. The hypothesis is strongly supported by the new observation, made by the Chicago group, that the incoming primaries are mesotron-producing ionizing particles which, unlike high energy electrons, do not excite showers in lead. We assume that the protons spend most of their energy-producing mesotrons with a wide energy distribution and that this occurs mostly within the first 5 per cent. of the atmosphere. The slower mesotrons, by disintegration into electrons and photons, are progenitors of the soft component, while the faster mesotrons may persist to the ground, appearing as the hard component. Good agreement, at least roughly quantitative, has thus been obtained with the observed depth-ionization curve, the latitude effect at different altitudes, and, as T. H. Johnson has previously shown, with the directional asymmetry of the penetrating component. Our interpretation of the low asymmetry of the soft component would follow that suggested by Swann. The evidence thus strongly indicates protons as the major, perhaps the only, component of primary cosmic rays.

Water masses and currents of the North Pacific Ocean:[1] H. U. SVERDRUP. The waters of the North Pacific can be considered as made up of five distinctly different water masses above a uniform deep water and covered by a thin surface layer. Perfect static equilibrium does not exist because the density of the water varies from one region of the ocean to the other, and water masses of different density can not remain next to each other unless currents are present. The equilibrium is therefore not static but dynamic, and is maintained by the prevailing currents and the changes to which the moving waters are subjected by contact with the atmosphere and by processes of mixing. The major currents of the North Pacific have the character of a series of clockwise circulations. The north and south equatorial currents flow to the west between the Equator and latitudes 20° to 25° N, and imbedded between them in latitudes 5° to 10° N the equatorial counter current flows east. Part of the water of the north equatorial current bends north when reaching the Asiatic islands and flows along the coast of Japan as the warm Kuroshio. In latitude 35° N the current turns east, one branch continuing due east and another taking a more northerly course. The water of the former turns gradually south, the greater part joining the north equatorial current to the west of the Hawaiian Islands and completing a clockwise circulation. To the east of the Hawaiian Islands and extending to about 400 miles from the American west coast is a smaller clockwise whirl which is in part linked with the bigger one to the west. The waters of the northern branch of the Kuroshio mix with the waters of the cold Oyashio and continue to the east as the cold subarctic current of the North Pacific which flows between the south coast of the Aleutian Islands and latitude 42° N. When reaching the American west coast, part of this water bends north into the Gulf of Alaska and part bends south, flowing as the cold California Current which can be traced to about latitude 25° N. The waters of the California Current mix with equatorial water and complete the largest circuit in the North Pacific as they join the west-flowing north equatorial current.

[1] Contributions of the Scripps Institution of Oceanography, New Series, No. 129.

The use of lethals to separate the components of heterocaryotic races of Neurospora: B. O. DODGE. The four-spored races of the *Neurospora tetrasperma* type have, as a rule, originally two nuclei of opposite sex in each ascospore. To use such forms in genetic work the components must be separated either by using dwarf ascospores or the minute conidia. *N. Toroi* seldom forms dwarf ascospores and the unisexual components less rarely become separated in vegetative growth. To overcome this handicap, the dominant lethal E has been used to induce the formation of many eight-spored asci in culture so that the ascospores are unisexual instead of bisexual. The number of unisexual races available for breeding work is, therefore, unlimited and they are readily obtained by growing the races into which the dominant lethal has been introduced on certain kinds of media. The recessive lethal *d*, which acts to suppress the production of conidia in the haploid vegetative condition, apparently is unable to function strongly as a lethal in the absence of the proper amount of agar. A sex-linked character which is manifested by a difference in the coloration of the mycelia and conidia of races of opposite sex is readily detected when they are grown on media with the proper amounts of Difco agar.

Genes in Datura which induce morphological effects resembling those due to environment: ALBERT F. BLAKESLEE and A. G. AVERY. Induced and spontaneous gene mutants which resemble the morphological effects brought

about by environmental factors are not infrequent in Datura. Thus two divisions of the pistil are characteristic of the genus Datura. An occasional tricarpel fruit, however, may be formed on a plant which is otherwise dicarpel. Such abnormal fruits are apparently due to environmental factors since the character is not inherited. However, a spontaneous mutation has arisen in our cultures which has given rise to a pure-breeding tricarpel race. Similarly, Datura is normally diforked, with an occasional plant which is triforked—apparently on account of environmental factors. However, a pure-breeding race has been found in nature which is normally triforked. Datura is susceptible to a number of virus diseases which produce characteristic changes in the plants affected. Some of the gene mutants show similar changes in appearance. One pure-breeding mutant type which is due to a recessive gene is of especial interest since it closely resembles in appearance the *quercina* virus disease. Both the *quercina* virus and the *quercina*-like gene cause the elimination of spines from the capsule, the division of the tubular corolla into individual petals and the production of narrow, eroded leaves. The *quercina* disease can be transmitted to a healthy plant by grafting, but this is not true of the *quercina*-like mutant type. It is apparent that genes and environmental factors may bring about similar end results through their effects upon the developmental processes in the plant. The similarity of the effects of certain genes and viruses suggests that they alter the internal environment in similar manner. Both virus and the determiners of heredity exist as discrete self-perpetuating particles, and both are subject to induced mutations. The similarity of their action supports the suggestion that the chief difference between the two may lie in the fact that the virus particle is free and hence capable of undergoing uncontrolled reproduction, whereas the gene is confined to a specific locus within the chromosome and its propagation is limited by the mechanism of heredity. The facts give support to the suggestion of an evolutionary relationship between viruses and genes.

Growth regulation of plants and formative effects induced with β-naphthoxyacetic acid: P. W. ZIMMERMAN (introduced by B. O. Dodge). Many growth substances have in common the capacity to induce similar responses in plants; that is, cause cell elongation, increase cell division and induce adventitious roots. There are, however, many qualitative differences in the capacity of chemically similar compounds to induce physiological responses. For example, β-naphthoxyacetic acid and its derivatives modify the new organs (leaves, stems, flowers and fruit) which are formed after the growing points are treated with the substance. The pattern and venation of compound leaves become modified, appearing frenched and fasciated. Leaflets frequently grow together on portions of compound leaves. Compound types sometimes become simple leaves and again doubly compound. Both the pattern and opaqueness of veins are modified. Veins of modified leaves show clearing, which is usually characteristic of virus-diseased plants. Tobacco plants sprayed at the tip with a solution (300 mg./l.) of β-naphthoxyacetic acid grow taller and flower ahead of controls. Treated delphinium plants also flower ahead of controls. Unless plants are retreated at intervals they recover and again produce normal leaves and flowers. Parthenocarpic development of tomato fruit is induced when flowers or well-developed buds are sprayed with emulsions or solutions of naphthoxyacetic acid. The ovaries often enlarge before the flowers open, eventually breaking through on one side of the calyx tube. The floral parts—petals, stamens and pistils—persist for an abnormally long time during the parthenocarpic development. In some cases both petals and stamens remain in good condition for thirty days whereas controls wither within three days after the flowers open. Compared with other growth substances naphthoxyacetic acid has several advantages for practical production of seedless tomatoes and possibly of other fruits. The results of these experiments show that formative effects can be induced under the influence of a known chemical compound. This may help to explain some of the observed phenomena in nature under the influence of natural hormones.

The relative position of cell walls in developing plant tissues: EDMUND W. SINNOTT and ROBERT BLOCH. In growing plant tissues the position of new cell walls is not fortuitous but has a definite relation to the position of walls already present in adjacent tissues. There are two main types of relative wall position: (1) Most commonly, a new wall avoids intersecting an old one at a point directly opposite the point of insertion of an adjacent partition wall, so that the walls alternate or "break joints" and only three meet at a point. This type can best be studied in tissues where the cells are in parallel rows and all new walls are in one plane. In such cases the degree of avoidance can be shown graphically. (2) In certain tissues just the reverse condition occurs, a new wall being formed directly opposite the point of insertion of a previous one, so that four walls meet at a point. This is frequently found in the cortex of roots, in polyderm and in normal and regenerative periderm. Developmental studies show that the factors determining the position of the wall do so very early by controlling the position of the plate of cytoplasmic strands, or phragmosome, long before the wall itself is laid down. For this and other reasons the liquid film hypothesis, commonly invoked to explain the alternating type of wall position, is regarded as inadequate. The opposite type of wall position seems to be related to local changes in the character of the mother-cell wall. Aside from their bearing on the general appearance of plant tissues, these facts are of significance in problems dealing with tissue cohesion, the production of aerenchyma and the number of faces of contact between cells.

Biotin and the growth of Fusarium avenaceum: WILLIAM J. ROBBINS. A strain of *Fusarium avenaceum* obtained from South America does not grow in a solution of mineral salts and sugar but grows on the same solution solidified with agar. The beneficial effect of agar on the growth of this organism is chiefly because of biotin (vitamin H) present in the agar. Purification of the agar by extraction with aqueous pyridine removes the biotin

and makes the agar ineffective in permitting growth of the fungus. The amount of biotin present varies with the sample of agar but approximates 0.1 microgram per gram in some samples. This is about one third the amount in dried egg yolk. Agar was more beneficial than could be accounted for by its biotin content. A beneficial effect of 0.001 microgram of pure biotin (obtained from Dr. Vincent du Vigneaud) on the growth of the fusarium in liquid culture was observed and amounts of biotin up to 0.1 microgram per culture further increased the dry weight. Some isolations made from old cultures of the fungus grew in the absence of biotin; these were interpreted to be saltations or dissociations.

New evidence concerning the configurations of the alpha and beta glucosides: C. S. HUDSON, EDNA M. MONTGOMERY, and NELSON K. RICHTMYER. Charles Tanret discovered in 1894 that the naturally occurring glucoside *picein* is converted to levoglucosan by the action of hot barium hydroxide solution. *Picein* is *p*-hydroxy-acetophenone-β-D-glucopyranoside. We find that β-phenyl-D-glucopyranoside is converted to levoglucosan similarly. On the other hand, α-phenyl-D-glucopyranoside is not affected by the alkaline treatment. These new facts prove the configurations of the alpha and beta glucosides, levoglucosan and similar anhydrides.

The electrophoretic study of complexes between proteins and related compounds: D. A. MACINNES and LEWIS G. LONGSWORTH. In our study of egg white, by a modification of the method of Tiselius, evidence was obtained that complexes exist between the proteins in the naturally occurring material and also in salt and buffer solutions. The evidence comes largely from the fact that in certain cases the electrophoretic patterns for the rising and descending boundaries are not, even approximately, mirror images of each other, as would be expected if the components were electrophoretically independent. The effect is greatest for relatively high protein concentrations, and low salt contents, of the solutions used in the studies. Complexes are most often found between proteins on opposite sides of their isoelectric points, but this is by no means a necessary condition for their occurrence. As type systems, electrophoretic studies have been carried out systematically with mixtures of ovalbumin and yeast nucleic acid, and on this nucleic acid with ovomucoid, varying the relative concentrations, the pH values and the ionic strengths. The electrophoretic pattern for a mixture of ovomucoid and nucleic acid is particularly interesting in that it indicates a peak for an extra component. The apparent relative concentrations, as indicated by the areas under the different peaks of the patterns, are altered by complex formation. With the mixture of ovalbumin and nucleic acid the components were found to form complexes if the pH were near or below the isoelectric point of ovalbumin, but to be electrophoretically quite independent at high pH values.

The role played by radiation mutations in mankind: H. J. MULLER. Calculations are presented of the average number of generations to be expected between the production of a recessive gene-mutation in man and its manifestation in a homozygous individual. The chance of the mutated gene meeting another like it that originated by an independent mutation depends on the frequency of such mutations, on the survival value of the abnormal type and on the randomness of breeding. Taking the maximal values for these factors (the values favoring the highest frequencies of recessive abnormalities), it turns out that at least 30 or, more likely, over 100 generations would on the average occur—i.e., 750 to 3,000 years or more—before a seriously harmful recessive abnormality (one having less than 90 per cent. of normal survival) would manifest itself by this process. Another mechanism of manifestation involves the meeting of two genes, each descended from the same original mutated gene. The frequency of this depends upon the total degree of inbreeding. A new method for gauging this is presented, involving the principle that the frequency of homozygosis from this cause is one fourth the frequency of marriages between two related individuals having the same name. From statistics on this point and on cousin marriages it is found that, even in the most closely inbred groups in modern civilized society, the chance of a mutated gene manifesting itself by this process is not over 0.5 per cent. This represents a "latent period" of some 5,000 years. Both processes together would give over 600 and probably thousands of years of latency. The large number of mutated genes accidentally dying out while thus "under cover" are compensated for by those accidentally multiplying. Thus the inherited damage from irradiation, though so long postponed, is in no wise prevented. Judging by results in mice (P. Hertwig), we may provisionally take the order of frequency of seriously harmful recessive mutations induced by 300 *r* as one to several per cent. (perhaps doubling the natural frequency). This chance of damage would seldom overweigh the direct benefits of diagnostic or therapeutic irradiations, excepting those designed to stimulate or temporarily inhibit reproduction. However, in irradiation intended for other parts, the gonads should be shielded. Natural radioactivity, while of no consequence in flies, may appreciably influence human mutation frequency. For the long duration of the human generation sometimes allows the reception of ten or more *r*. Thus, under special conditions, the amount might conceivably be enough to be significant in evolution.

The control of ovum growth: GREGORY PINCUS (introduced by H. J. Muller). Rabbit ova were cultured *in vitro* under conditions which allow definite but limited blastocyst growth. An analysis of the processes controlling ovum growth was undertaken by adding to the cultures (1) various substances which are specific poisons for known components of carbohydrate-splitting enzyme systems and (2) various presumable substrates and growth-promoting substances. Ovum growth was found to be inhibited by low concentrations (10^{-4} to 10^{-5} M) of the following poisons: cyanide, iodoacetate, fluoride, selenite. Partial growth inhibition was exerted by high concentrations of glyceraldehyde and malonate. The following putative substrates were ineffective as growth stimulants:

glucose, glucosephosphate, oxalacetate, malate, succinate, fumarate, lactate. Neither riboflavin nor coenzyme I was growth-stimulating. Pyruvate in moderate concentration (0.003 M) proved an effective growth stimulant. The growth-inhibiting effect of fluoride was overcome by pyruvate. Vitamin B1 proved an excellent growth stimulant, as did the sulfhydryl compounds glutathione, cysteine and thioglycolic acid. Insulin was moderately growth-stimulating. Ova fail to grow under completely anaerobic conditions. These findings are taken to indicate that the energy for growth is derived (1) at least in part by an oxidative process, (2) by the glycolytic degradation of carbohydrate, and (3) chiefly by the action of a phosphorylating enzyme system. The limiting process appears to involve the metabolism of pyruvic acid since (1) the poison (fluoride) inhibiting the production of pyruvic acid may be counteracted by addition of pyruvate in excess, (2) vitamin B1 probably functions as part of a pyruvate splitting system, (3) the sulfhydryl compounds may act as cocarboxylases to a system affecting the decarboxylation of pyruvate. Insulin may act as a donor of sulfhydryl-containing substance. Pyruvate appears normally to be derived from triose phosphate and not from oxalacetic acid since the latter was not growth-stimulating, whereas the former was. The relation of these findings to hormone-controlled growth *in vivo* and the utility of these methods for determining the nature and necessities of embryo nutrition will be indicated.

Morphological changes in amputated nerveless limbs of urodele larvae: OSCAR E. SCHOTTÉ and ELMER G. BUTLER (introduced by E. Newton Harvey). By repeated resections of the brachial plexus, forelimbs of Urodele larvae have been maintained in a nerveless condition for several weeks and in some cases for as long as two months. A limb, completely devoid of spinal innervation, not only loses its capacity for regeneration, but also, after amputation, it undergoes radical morphological changes. Beginning at the level of amputation and proceeding proximally, structures of an amputated nerveless limb undergo regression and resorption. This structural regression brings about extreme reduction in size and eventually complete disappearance of the limb. Histological studies demonstrate that the regression is the result primarily of cellular dedifferentiation. All formed structures of the limb, including skeleton and muscles, go into extreme dedifferentiation and gradually disappear. Moreover, dedifferentiation in a nerveless limb involves not only those structures injured at the time of amputation, but also those remote from the amputation level. Articulations do not serve as barriers to the dedifferentiative processes. Amputation through the metacarpals, for example, results in dedifferentiation and disappearance of metacarpals, carpals, radius, ulna and most of the humerus, together with all other tissues in these regions. In such a case, fourteen skeletal elements are involved in the dedifferentiation, thirteen disappearing completely, although only four of these structures were injured at the time of amputation. These radical morphological changes are not the result primarily of physiological atrophy, but represent alterations in the specific character of limb tissues, caused by the disturbed unrolling of regenerative processes. Since control experiments show that denervation alone only impedes further growth processes, but is not followed by regression of structures, the above results reveal the importance of amputation for the normal course of regeneration. Unamputated nerveless limbs exhibit no dedifferentiation; amputated nerveless limbs show extreme dedifferentiation and reduction, leading to eventual disappearance of the limb. The nervous system, therefore, formerly regarded as exerting primarily a trophic influence on cellular activities during regeneration, must now be considered as an important agent of the organism as a whole, enabling amputated limbs to carry on the complex cellular interactions for regeneration.

Developmental variations resulting from the androgenetic hybridization of four forms of Rana pipiens: K. R. PORTER (introduced by James B. Murphy). Removal of the second maturative spindle of the frog's egg following entrance of the sperm nucleus, deprives the egg of its pro-nucleus and permits the association of nuclei and cytoplasms from different species or different races of the same species in the formation of heterospermic haploid embryos. This procedure has recently been employed to combine reciprocally the nuclei and cytoplasms of what appear to be four different geographic races of *Rana pipiens*. A comparative study of the early embryology of the one homospermic and the three heterospermic haploids resulting from the combination of any one type of cytoplasm with all four types of nuclei shows: (1) that the morphogenesis of the heterospermic haploids differs from that of the homospermic control; (2) that the variations shown appear to be of the same *order* but of a different *degree;* (3) that if the nucleus is derived from a more northerly source than the cytoplasm the departure from the normal is in one direction, if from a more southerly source, in the opposing direction; (4) that in general the further removed the nuclear source from the cytoplasmic the greater the degree of variation. Comparative examination of diploid control and hybrid embryos resulting from combinations of the same gametes reveals the same features though not so pronouncedly. When the data derived from using various cytoplasmic types in combination with the four nuclear types are brought together and compared, it is possible to observe the results of combining different cytoplasms with the same nucleus. From the standpoint of comparative morphogenesis these results show the features listed above. It is concluded that the cytoplasms used differ in factors which influence early development and, in terms of morphogenetic expression, it appears that the variations in these factors are related in some way to the geographic distribution of the parent races. The same can be concluded concerning the four types of nuclei used.

Studies on pain: measurement of the threshold for an alarm reaction in man and its relation to pain perception: J. D. HARDY, H. GOODELL and H. G. WOLFF (introduced by Eugene F. DuBois). The thermal stimulus necessary to evoke a barely perceptible change in skin resistance was measured. This change in skin resistance is a type of

alarm reaction. The method was essentially the same as that described for the measurement of the pain threshold. Heat from a 1,000-watt lamp was focused by a condensing lens onto the blackened skin of the forehead for exactly three seconds. The intensity of the radiation evoking a reaction was measured by means of a radiometer. It has previously been demonstrated that the intensity of stimulus required to produce pain was the same regardless of the size of the skin area stimulated, and was approximately uniform in all individuals. In contrast to this uniformity in the threshold for pain are the wide variations which occur in the threshold of the alarm reaction. It was observed that the intensity of radiation necessary to evoke a reaction was less with large areas of exposed skin than with small. With the large areas, ca 30 cm^2 the threshold of reaction was as small as 0.08 that of the pain threshold and varied appreciably from time to time in the same person, and from person to person. For areas of skin smaller than 3 cm^2 the threshold of reaction was not so variable and usually approximated the pain threshold. It was inferred that the greater degree of discomfort experienced with the larger areas of exposed skin was due to the spatial summation of sensations of heat and warmth; that the reaction threshold was less variable with the smaller areas, due to the fact that a reaction usually followed when the pain threshold had been reached, and the latter was independent of the size of the area exposed. It was concluded, also, that the reaction after stimulation of the small area is due to pain, and with the large areas to the state of alertness or alarm resulting from the strong sensation of heat or warmth. The threshold level of the alarm reaction appeared to be related to the emotional state of the subject at the time. The administration of an analgesic agent such as acetylsalicylic acid when large areas were exposed raised the alarm reaction threshold to the pain threshold, and in the case of alcohol, higher than the pain threshold.

Hormones capable of increasing liver fat: OSCAR RIDDLE and DAVID F. OPDYKE. Hormones derived from the ovary, pancreas, adrenal and especially from pituitary glands have been studied with reference to their ability to increase the storage of fat in the livers of young pigeons and rats. Since unlike results were obtained with these two species this report is restricted to effects produced in pigeon livers following daily treatment during two to four days. Neither leuteinizing hormone, adrenotrophin, intermedin nor the inseparable mixture of gonadotrophin and thyrotrophin increases liver fat when those hormones are used in the purest form now available. Prolactin usually, but inconsistently, increases the liver fat in pigeons (not in rats) though it regularly increases the size of hepatic cells in pigeons. Insulin, desoxycorticosterone acetate and estrone all increase liver fat. Anterior pituitary fractions obtained by ammonium sulfate precipitation, with dialysis of precipitates formed at one-third (and one-half) saturation, have resulted in appreciable concentration of liver fat activity in the water-soluble portion of the precipitate formed at one-third saturation. This fraction contains notable quantities of adrenotrophin, thyrotrophin, gonadotrophin and (traces of) posterior-lobe hormone, but it is almost free from prolactin. The "pseudoglobulin" fraction (*i.e.*, the water-soluble part of the precipitate formed at one-half saturation) obtained in this series (done according to Young, 1939), though contaminated in fairly equal degree with all the hormones listed above for the highly potent fraction (and likewise almost free from prolactin), is practically free of liver fat activity. Pituitary extracts apparently show liver fat activity in all or many species, but it is not probable that this activity is produced by a single substance and not yet proved that an extract which is effective in one species is widely effective in others. This investigation was supported by a grant from the Committee on Research in Endocrinology, National Research Council.

Field properties of the developing frog's egg: H. S. BURR (introduced by L. L. Woodruff). The present report is a study of some six thousand determinations on fifty frogs' eggs prior to the development of the long axis of the embryo as seen in the appearance of the medullary plate. Potential differences between the vertex of the animal pole and four equidistant points on the equator of the egg were measured by the Burr-Lane-Nims technique. Three variations in the technique were employed and all were subjected to statistical analysis. From the very beginning it was apparent that at least one of the four points showed a significantly greater voltage drop from the vertex than any of the other three. This point was then marked either by staining by Nile Blue sulfate or by the establishment of orientation points in the immediate environment of the egg. Of the fifty embryos, ten were marked successfully and developed to the neural plate stage. In the remaining forty, correlations were either not attempted or were impossible because of technical difficulties. It should be noted that the technique is rigorous and requires great care in its manipulation, and technical artefacts therefore frequently creep into the study. In every case where correlations were possible, the primary axis of the organism came to lie along the plane which showed the greatest voltage drop from the vertex. In other words, it was possible to predict from the voltage pattern where the head end of the organism would develop. It is hard to escape the conclusion, therefore, that the electrical pattern is primary and, in some measure at least, determines the morphological pattern. Added weight is given to the argument by the following facts. Typical field patterns have been observed in the unfertilized egg where they last for three or four days after laying. When obvious signs of cell death appear, the voltage gradients disappear. In like manner, the same pattern is to be seen in the fertilized but undivided egg. Moreover, it can be followed through the early stages of segmentation, the formation of the morula, the gastrula, and even shows the same characteristics in the early medullary plate stage. It seems clear from the above that, at least in the frog's egg (and in the egg of Amblystoma, for some preliminary studies in the latter confirm these findings) there exists an electrical field which appears prior to the appearance of the formed structures and also predicts the longitudinal axis of the future embryo.

The methods of excitation of melanophores in the skin of the catfish Ameiurus: G. H. PARKER. To test the possibility of direct action of neurohumors on the melanophores of such a fish as the catfish, it is necessary first of all to to denervate the melanophores. The older technique of nerve cutting and scale removal supposed to accomplish this step really failed, for it left remnants of living nerve attached to the melanophores. To remove this last nervous remnant fishes must be kept alive after the operation some two weeks, thereby insuring nerve degeneration. When catfishes thus treated are tested by injection of intermedine, acetylcholine or adrenaline, the three normal chromatic neurohumors of this fish, their denervated melanophores respond as their innervated ones do. It is therefore concluded that these three neurohumors act directly on catfish melanophores, intermedine and acetylcholine expanding these cells and adrenaline contracting them. Intermedine originates in the pituitary gland of the catfish and is carried in its blood and lymph to its melanophores. Acetylcholine and adrenaline are products of its two sets of chromatic nerve fibers and are discharged in close proximity to the melanophores. These neurohumors appear first to enter and be stored in the lipoids of the tissue close to the color cells and to escape later from these protective reservoirs in solution in the lymph and thus to reach the color cells. In this way acetylcholine and adrenaline may be stored, protected and subsequently used, as they pass from the nerves to the melanophores in contrast with intermedine, which appears not to be subject to this kind of storage.

Anthropological connections between America and Siberia: ALEŠ HRDLIČKA. Since 1926, under the auspices of the Smithsonian Institution, systematic anthropological researches and excavations were carried on in Alaska. They resulted in the accumulation of extensive and comprehensive skeletal materials from the territory, now deposited in the U. S. National Museum. The study of these collections, thanks to the Soviet authorities and men of science, it was possible in 1939 to supplement with that of approximately 600 crania of various Siberian populations, from the Neolithic times onward. As partly reported to the academy at its last annual meeting, the Neolithic skulls from the Angara and upper Lena region showed remarkable similarities with the oblong type of skull of the American Indian. It is now possible to supplement this with the evidence shown by the more recent Siberian, and the Alaskan as well as other American materials. The total is based on approximately 4,000 normal adult crania, the essential metric data on which are now ready for publication. These data show definitely a close affinity between the aboriginal Siberians and Americans. In some instances the relation between a Siberian and an American group is so close as practically to amount to identity. And similarly some of the Old Alaskan resemble certain mainland American groups. The now available evidence makes it possible, in brief, and besides the Neolithics who have already been discussed, to identify the Eskimo with the Chukchi, and the Aleuts with the broader-headed type of the Tungus; nor do the resemblances stop there. In addition, the crania of the newly discovered Pre-Aleuts are seen to show a very near resemblance to the Siouan type; those of the similarly newly found Pre-Koniags of the Kodiak Island to the Algonkin type; and those of the Koniags, the people found on Kodiak at the advent of the Russians, with the southern Indian Alaskans. Thus, from the physical point of view, which alone can be reliable in the classification of human groups, America may now be definitely connected with Siberia, and Alaska with the rest of America.

The causes of migration within the United States: E. L. THORNDIKE. Measures of the attractive power of one state over another were computed for each of the 1,128 pairs of states. Measures were obtained of the differences between each pair of states in longitude west, latitude north, predominance of agriculture relative to manufacturing, per capita income (more exactly an index paralleling it), the general goodness of life for good people, and other variables, eighteen in all. An analysis of the relations between the ratio

$$\frac{\text{Born in state A but residing in state B}}{\text{Born in state B but residing in state A}}$$

and the difference measures (longitude of state B minus longitude of state A, latitude of state B minus latitude of state A, income index of state B minus income index of state A, etc.) by the methods of multiple correlation showed such facts as the following:

Let M = the measure of interstate migration

$$\frac{\text{Born in state A residing in state B}}{\text{Born in state B residing in state A}}.$$

Let L = the longitude (west) of state B minus the longitude (west) of state A.
Let I = the income index of state B minus the income index of state A.
Let G = the general goodness index of state B minus the general goodness index of state A.

Then, for native-born Negroes alive in 1930, the variation in M is "determined" or, in the common-sense meaning of the word, caused:

52 hundredths by what is measured by I and not by L or G
8 hundredths by what is measured by L and not by I or G
3½ hundredths by what is measured by G and not by I or L
25 hundredths by what is common to I and G
3 hundredths by what is common to I and L
2 hundredths by what is common to G and L
6½ hundredths by factors not measured by L, I or G

The fauna of the Uinta Eocene: W. B. SCOTT. The Uinta formation, so-called from the Uinta Mountains, along the southern flank of which it lies, is unquestionably referable to the Upper Eocene. It is plainly divisible into three parts, which in ascending order are called, respectively, A, B and C. Relatively speaking, the fauna is not very rich, obviously due to the conditions of preservation. The number of genera of mammals so far named in the fauna is 55 as compared with 102 of the White River, which succeeds the Uinta after an interval. Fishes are known only from fragments; lizards and snakes have not been found, but large crocodiles continue from the Bridger formation, which directly underlies the Uinta, indicative of a warm climate. The mammals are in a most interesting way transitional between those of the older Bridger and the succeeding White River. A number of genera

hold over from the Middle Eocene or are but slightly modified successors of the Middle Eocene genera. The primitive Carnivora referable to the sub-order Creodonta continue in considerable numbers. The true carnivores, Fissipedia, are few in number and restricted to the group of primitive dogs. No other family of Fissipedia has been found. Most of the fossils, as is generally the case, are those of hoofed animals and these are likewise of a transitional sort. We find here the last of the extraordinary six-horned Dinocerata, which are so characteristic of the Bridger, occurring in the Lower and perhaps the Middle divisions of the Uinta and then disappearing. Perissodactyla are still of the Bridger type and are very numerous and diversified. Most of them belong to the family of the brontotheres, and some of these have developed horns of a very conspicuous type. The most striking change, as compared with the Bridger, is in the great number of Artiodactyls. Aside from certain pig-like forms the great bulk of these Artiodactyls were ruminants and allied to the camels. Almost all the White River families of Artiodactyls are represented in the Uinta, but all these families are much closer together than the White River descendants are, indicating their convergence backwards to a common ancestry. The smaller mammals are extremely scarce in the Uinta beds so that the number of rodents is much less than we believe to have lived at that time. I have undertaken to prepare for the American Philosophical Society a Monograph of the Uinta Mammals, which will be prefaced by a stratigraphical study by Dr. John Clark, of the Carnegie Museum of Pittsburgh.

The correlation of the Cambrian formations of northeastern North America with those of other parts of the continent: B. F. HOWELL (introduced by Arthur Keith). Until recently stratigraphers have been unable to correlate satisfactorily the Middle and Upper Cambrian formations of Newfoundland, eastern Canada and New England with those of other parts of North America. The discovery of additional faunas in Newfoundland, Quebec, Vermont, the southern Appalachians, the western United States and the Canadian Rockies, and a consequent better understanding of the age relationships of the Cambrian faunas of the entire continent, now make the correlation of the northeastern formations with those of the south and west feasible. The succession of Cambrian strata in the northeast, previously believed to represent most of Cambrian time, is now found to present a very incomplete sedimentary and faunal record. A more complete record can be pieced together from other quarters of North America, and this enables us to interpret the fragmentary northeastern succession. Many genera of fossils are now known to have had a geographic range which embraced both the northeastern area and other parts of the continent. Since the faunas of the northeastern region are very similar to those of northwestern Europe, while the faunas of western North America resemble those of eastern Asia, stratigraphers can now make better correlations than heretofore of Cambrian formations throughout both hemispheres.

Further light on the origin of the Carolina "Bays": DOUGLAS JOHNSON. In earlier papers evidence has been presented to show that the supposed meteorite scars of the Carolina coast are the product of artesian spring action accompanied by solution which produced basins occupied by lakes, the waves of which built beach ridges about the shores, while dominant winds transported sand to form larger dune ridges having major development around the southeastern quadrants of the depressions. Airplane photographs recently available demonstrate that in certain areas the basins are pear-shaped rather than oval, and have their major axes oriented more nearly north-south than do the oval basins first discovered. The new evidence available seems to negative the meteoritic intrepretation of "bays" origin, and to support the hypothesis of terrestrial origin outlined above.

The batholith of southern California: ESPER S. LARSEN (introduced by Arthur Keith). The great batholith of Southern California underlies a strip from 60 to 100 miles wide and 1,000 miles long from near Riverside, California, to the southern tip of Lower California. It is larger than the batholith of the Sierra Nevada, to which it is probably closely related. The elongation of the batholith is essentially parallel to the structure of both the older and younger rocks. Its age is Late Jurassic or Cretaceous. A strip across the batholith and 70 miles along its length was studied by the author as a sample of the batholith. This strip is made up of many separate injections and for the most part early injections had become largely crystalline before succeeding magmas were intruded. The succession of intrusions was from gabbro to granite. The average rock is a tonalite. The gabbro and granodiorite are confined to the western part of the batholith. Thirty-four chemical analyses of carefully selected rocks of the batholith are plotted on a variation diagram. All but a few fall near a smooth variation curve. This curve is somewhat different from that for the Sierra Nevada batholith. Dark inclusions are present in all the rocks and they are abundant in some. They tend to be disc-like and subparallel. The form of the individual intrusive bodies and their relations to the wall rocks indicate that the magmas were emplaced by stopping and not by forcible injection. The first intrusion, a gabbro, represents the primary magma, and the other magmas were formed by a combination of crystal differentiation and assimilation. Most of the larger mapped units of the batholith are present in several bodies that are widely separated. Only a few of these bodies underlie areas as large as 200 square miles. The relative uniformity of the various bodies of any particular intrusion can not be due to the fact that all the bodies come from a single well-mixed, uniform, deep-seated magma. It seems much more likely that widespread diastrophic forces formed the long body of magma and that later diastrophism determined the stages in differentiation at which bodies of magma were moved toward the surface. Some intrusions were preceded by shattering and mixing of fragments of the wall rock in a large body of magma. In one widespread tonalite the inclusions must have been incorporated in the magma shortly before its final emplacement, as they were almost completely reacted on, softened, and drawn out but not disintegrated. In another the inclusions were disintegrated but not com-

pletely assimilated, indicating more mixing but less assimilation. Local diastrophism emplaced the several small bodies of granite and the numerous small, local bodies of other granitic rocks.

Basement influence on Rocky Mountain structures: ROLLIN T. CHAMBERLIN. The more the Rocky Mountains are studied, the more it becomes evident that pre-existing structures and strength variations in the underlying basement rocks have had great influence in determining the pattern of the present ranges and the nature of yielding under the Laramide compression which produced them. Where the complex crystalline rocks were deeply buried beneath a thick cover of weaker geosynclinal sedimentary strata, the latter were folded with relative regularity in long, linear, nearly parallel ranges which extend through many degrees of latitude. But in the foreland area to the east, where only 10,000–15,000 feet of Paleozoic and Mesozoic strata overlay the basement complex, the structures and rock differences of the latter were sufficiently close to the surface to exert a strong control which upset the regularity of the Rocky Mountain deformation. The result was an uplifting of variously oriented block-like or oblong ranges and a sinking of basins of quite irregular pattern. The basement control was manifested chiefly in two ways. (1) Pre-existing zones of faulting in two cross sets (roughly north-south and east-west) have outlined rectangular areas which deformed each with a certain individuality of its own. In south-central Montana block-like areas were moderately uplifted without much tilting. Differential horizontal movement also occurred, particularly on the east-west lines, the south block in each case shifting east relative to that on the north. To the south, much stronger uplifts developed the Beartooth, Pryor, Bighorn and other mountain groups far east of the Rocky Mountain front in northern Montana and Canada. The crustal adjustment involved in this easterly offsetting was accomplished in part by the differential horizontal shifting. These mountain groups are composed of transverse subunits, some tipped up most on the northeast, others on the southwest, developing a remarkable reversal of asymmetry in alternating segments of the ranges. (2) The Laramide folding of the Beartooth, Bighorn and Black Hills has also accentuated old pre-Cambrian dome-like uplifts with batholithic cores. These outlines, however, are at variance with the block fracturing; but in places the two have combined in a composite basement control. The individuality of the foreland ranges, their divergencies from the general northwest-southeast Rocky Mountain alignment and their particular behavior have resulted from this composite control. The numerous minor folds, involving chiefly the sedimentary cover, have been much less influenced by the basement and follow closely the regional northwest-southeast Rocky Mountain trend.

Biographical memoir of David Watson Taylor: WILLIAM HOVGAARD.

OBITUARY

ANNIE JUMP CANNON

ON the thirteenth of April, 1941, the world lost a great scientist and a great woman, astronomy lost a distinguished contributor and countless human beings lost a beloved friend by the death of Miss Annie J. Cannon.

Miss Cannon was born in Dover, Delaware, in the year 1863. In days when an education for women is easily come by, it is hard to appreciate the enlightenment of a parent who was willing to further a daughter's "higher education" in the seventies and eighties of last century. Her father gave effect to her early delight in the phenomena of nature, and she entered the class of 1885 at Wellesley. Not long ago she was recalling those early days; one might have expected the girls to be very serious and earnest, she said; but they always seemed to be laughing. And in that spirit she went through life, always endowing what seemed to many people an impossibly laborious and exacting occupation with joy and vitality.

After completing her studies at Wellesley, Miss Cannon came in 1896 to the Harvard Observatory, then under the directorship of Edward C. Pickering; and here for the first time she began those studies of stellar spectra with which her name will always be associated, although they were by no means the sum total of her contribution to science. The study of the spectra of the southern stars, published in 1901 in Volume 28 of the Annals of the Harvard College Observatory, was her first major research. This work is still a treasure-house of information for the student of stellar spectra, but its greatest interest probably lies in the fact that the system of spectral classification that later came into general currency was here crystallized for the first time.

The Henry Draper Catalogue (named in honor of the first man to photograph stellar spectra) was the outcome of the earlier studies of stellar spectra; and when the means were available for the execution of the immense task of classifying the spectra of almost a quarter of a million stars, it was Miss Cannon whom Pickering selected for carrying it out. Of the value of the Henry Draper Catalogue to science it is almost unnecessary to speak; there is not a branch of astronomy or astrophysics that has not drawn upon it, and will not cease to draw upon it for many years to come. But perhaps it is not unbefitting to speak of the labor that was involved in producing so great a work. The classification of the spectra themselves—most of them from more than one photograph—though a great undertaking, was by no means the major part of the work; it was carried out during the space of only