The National Academy of Sciences:

Abstracts of Papers Presented at the 1949 Annual Meeting

The Future of the Quantum Mechanical Theory of Chemical Binding

Robert S. Mulliken, *University of Chicago*

Not long after its inception in 1925–6, quantum mechanics gave the first real qualitative and roughly quantitative explanation of the formation of molecules of the covalent type. In the period 1927–35 many of the most able theoretical physicists and chemical physicists explored the possibilities of a really accurate quantitative understanding of molecular forces and energies by the use of quantum mechanics. While the reliability of this theory as a basis for handling such problems was established without question, its practical application for accurate computations was found to be beset with mathematical complexities. As a result of this situation and of the wartime focusing of efforts on problems of nuclear energy and nuclear structure, the further development of this important and potentially very rich field has been grossly neglected, especially in this country. But in spite of the discouragements hitherto encountered in attempts at quantitative accuracy, the writer is optimistic as to the future possibilities for at least moderate success in this field; though probably only by a more patient, more systematic, and more comprehensive program of study than that of the pioneers. Some results which may be a step in the direction of such a program were outlined at the meeting.

Detection and Measurement of the Size of Aerosol Particles in the Range below Tyndall Beam Detection

Victor K. LaMer, Irwin B. Wilson, and Edward C. Y. Inn*

Columbia University

The intensity of the light scattered by a small aerosol particle decreases as the inverse sixth power of the radius. Accordingly, the practical lower limit of detection is about 0.03 μ and of measurement by direct optical means is about 0.1 μ. Aerosols of smaller (uniform) size are prepared by heating 99% H_2SO_4 in the LaMer-Sinclair homogeneous generator. No Tyndall beam can be detected. The particles are then grown by a factor of 2- to 10-fold in radius, corresponding to 8- to 1000-fold in volume, or 64- to 10^6-fold in light scattering power, by passage over a solution of H_2SO_4 of known water content. Aqueous tension equilibrium is established promptly and the particle grows to a size fixed by the H_2SO_4–H_2O composition of the master solution.

* Navy contract ONR-271-16.

The number and radii of the grown particles are then determined by the rapid optical methods described previously (see *J. Colloid Sci.*); the size of the original nondetectable particles is then easily calculable from the known absorption of water vapor.

Composition of Meteoritic Matter, Nuclear Shell Structure, and the Principle of Regularity and Continuity of Series

William D. Harkins, *University of Chicago*

In 1917 the following principle was introduced into nuclear science (W. D. Harkins, *J. Am. chem. Soc. 39,* 856): the abundance of elements (nuclear species also—1921) is determined by their nuclear relations. Among these, nuclear stability is fundamentally important. However, since in most nuclear reactions (aside from fission) at energies less than 50–100 Mev only neighboring atomic species are involved, the origin of nuclei and their growth by nuclear reactions determine what nuclei are formed.

It was assumed that the very lightest atoms are formed from hydrogen (protons) but heavier atoms from neutrons. The first important relation to be discovered was predicted by a theory of the writer: in the meteorites elements of even atomic or proton number are much more abundant than those of odd number, and also each even element is more abundant than either of the two adjacent odd elements.

An even more striking fact is that *very few atoms* are stable if N is odd, and none *with both* N *and* P *odd,* unless $N = P$.

TABLE 1

Class (N = neutrons; P = protons)				Abundance in atomic percentage: Earth's crust	Abundance in atomic percentage: Meteorites
Class I	N—even	P—even		87.4	95.4
Class II	N—even	P—odd		10.8	2.1
Class III	N—odd	P—even		1.8	2.5
Class IVa	N—odd	> P—odd		0.0	0.0
b	N—odd	= P—odd			
			(Heavy hydrogen, Li^6, B^{10} and N^{14})*		

* Nitrogen, N^{14} (7 neutrons, 7 protons) is the only species of Class IV which is abundant (in the stars).

The isotopic number $I = N - P$. If the species of even mass ($M = P + N$) are plotted as a function of P and I for meteorites, planets and stars, the species of even mass fall into continuous series, except for five blanks, with every odd P missing, but (1) *each* of these five undis-

covered species occurs *adjacent* to the end of a shell, where the abundance is high.

In the series of odd mass there are only seven undiscovered species, but (2) each of these is "forbidden" by the principle that both of two adjacent isobars are not stable unless the difference in nuclear spins is very large.

At present 167 stable atomic species of even and 108 of odd mass, or 275 in all, are known. The principle of continuity alone indicates five additional species of even and eight of odd mass, but in each of these 13 cases either relation 1 or 2 above indicates a probable instability. Thus it is not improbable that all of the stable species are now known.

Stars with Atmospheres of Glowing Hydrogen

Paul W. Merrill

Mount Wilson and Palomar Observatories

Stars whose outermost strata are unusually active offer special inducements to astrophysical research. The first problem is to find them. The classical method has been to search for stars that vary in brightness. But this method does not cover the whole field because rapid motions and other interesting phenomena occur in certain stars that exhibit no appreciable variations in brightness. This is particularly true of hot stars with extensive atmospheres containing glowing hydrogen. These atmospheres cannot be seen or photographed directly but may be detected by the bright hydrogen lines they add to the stellar spectrum.

The Mount Wilson search for bright-line objects, begun in 1919, combined the advantages of objective-prism photography with the use of the red Hα line, the strongest accessible line of hydrogen. Of the 1000 bright-line B-type stars now known about 800 have been discovered in the Mount Wilson survey. A number of these are of interest because of phenomenally rapid atmospheric motions. In DM–27° 11944 an outflow of gas at the rate of 300 km/sec has continued since 1921. In 48 Librae a mighty atmospheric oscillation began in 1934; it has a period of about nine years with heavy damping. In the shell star HD 193182, 40 hydrogen lines have been photographed in the Balmer series.

Two important related investigations have grown out of this program. One is the discovery by R. Minkowski of 200 planetary nebulae; the other, the discovery by A. H. Joy of 40 T Tauri stars near the edges of dark galactic clouds.

Some Problems of the Evolution of Stars

Otto Struve, *Yerkes Observatory*

Shapley has shown that the W Ursae Majoris eclipsing binaries are more numerous that all other eclipsing variables taken together. These strange systems consist of two late-type stars, almost in contact, of about one solar mass and one-half solar mass, respectively, both slightly smaller than the sun. They are surrounded by a common gaseous envelope which is unsymmetrical in thickness and other physical properties, suggesting that the binary is not a stable formation but that it may develop either in the direction of forming ultimately a single star or of separating into a wider pair. Each binary system carries with it a large amount of angular momentum. Yet there are not now known any single stars with the required angular momentum which could be regarded as the parent stars or as the descendant stars of these binaries. They may have originated from early-type binaries of the kind of β Lyrae or U Cephei through prominence action in their advancing hemispheres, resulting in the production of gaseous streams. These streams not only carry off mass at a rate of not less than $10^{-8} \times$ sun's mass per year but they also carry off angular momentum in a manner that is not altogether different from the mechanism suggested in 1947 by v. Weizsaecker. If this process of evolution should continue then the common gaseous envelope of a W Ursae Majoris system may be identified with the v. Weizsaecker nebula giving rise to the beginning of a planetary system and thus the slow rotation of the resulting single stars can be explained.

Values as a Subject of Natural Science Inquiry

A. L. Kroeber, *Columbia University*

"Human values" are defined as human products forming part of human culture and hence as fully natural phenomena, subject to study by the methods of natural science. Any extranatural or supernatural properties sometimes ascribed to values may therefore be ignored. *De facto*, anthropologists and others have actually often dealt with value from a genuinely scientific attitude, though not always aware of the fact. The importance of values is in their organization and integration of culture. This function is more readily discerned than the specific causes which produce values.

Forecasting Features of Washington Weather

C. G. Abbot, *Smithsonian Institution*

Author publishes annually "preferred" dates for precipitation at Washington based on the rotation period of the sun. For 15 consecutive years the average daily precipitation on "preferred" dates has been above that for all others. The 15-year average ratio is 1.46, the expected ratio 1.42.

In January 1948 author deposited a sealed list of 55 dates in 1948 which he predicted would be near dates of minimum temperature at Washington. He predicted that between these pairs of dates would lie others averaging for the year 7.1° F higher. The director of the Astrophysical Observatory opened the package January 19, 1949, and certifies that on 48 out of 55 cases warmer days did thus intervene. Their average excess was 6.96°,

as against 7.1° predicted. The prediction is based on a 6.6456-day regular period in solar variation. Author claims this solar influence nearly completely accounts for the short interval fluctuation of temperature in weather. He believes similar predictions would succeed anywhere.

Structure and Dynamics of the Thunderstorm

Horace R. Byers, *University of Chicago*

From the extensive and detailed data obtained by the Thunderstorm Project in Florida and Ohio, a model of a thunderstorm has been established. There are several more or less independent convective systems of "cells" which make up the thunderstorm. Each cell goes through a life cycle represented by three fairly distinct stages—the cumulus stage, the mature stage, and the dissipating stage.

In the cumulus stage the cell is formed from an updraft of air which, as in the other stages, "entrains" air from the environment. In this stage no rain has yet reached the ground. In the mature stage, rain is occurring and a large part of the cell consists of a downdraft which coincides with the rain area. The updraft continues in a portion of the cell. In the dissipating stage downward motion predominates.

In a study of the thermodynamics involved in these circulations it is shown that the entrainment of environment air into the cells has important effects. The significance of falling rain in starting the downdraft is shown. The downdraft consists of cold air that reaches the ground and spreads out over the surface of the earth, producing marked changes in the wind, temperature, and pressure. The thunderstorm derives energy from the downdraft as well as from the updraft.

The Panama Land Bridge

W. P. Woodring, *U. S. Geological Survey*

The Panama land bridge is more fantastic in outline than many land bridges that have foundations no more secure than the imagination of paleogeographers and zoogeographers. Inasmuch as it still is a bridge in being and ample evidence indicates that it has been in continuous operation since late Tertiary time, its record may serve as a test for the performance of hypothetical bridges. Unlike many hypothetical bridges, it was not narrowly selective to potential users—indeed, it was less selective than it now is—and it accommodated two-way traffic, as every genuine bridge should, although the southbound lane was more crowded than the northbound. According to vertebrate paleontologists familiar with the Tertiary land mammals of North and South America, the Panama bridge was completed and open to traffic immediately after the end of middle Pliocene time, about 5 million years ago. The first North American migrants, however, reached South America in the late Miocene or early Pliocene, and the earliest South American invaders reached North America in the middle Pliocene. These first arrivals in both continents were small animals and presumably reached their destination by using still separated spans and completed piers as stepping stones.

A land bridge is also a sea barrier, and erection of the Panama bridge evidently had a profound effect on marine animals in the Caribbean Sea. Sweeping extinction of scores of genera, which may be designated paciphiles, as they are still living in the Pacific Ocean and probably had their origin there, took place in the Caribbean Sea during and immediately following early Pliocene time. On the contrary, very few caribphiles became extinct in the eastern Pacific Ocean, possibly because the ancestral eastern Pacific Ocean was a much larger body of water than the ancestral Caribbean Sea, and therefore was not so greatly affected by disruption of long-established circulation of ocean water masses through Central American seaways.

The Principles of Generalized Harmonic Analysis Applied to Ocean Wave Data

H. R. Seiwell, *Woods Hole Oceanographic Instituiton*

(Introduced by John A. Fleming)

A fundamental problem of sea surface wave research is the reduction of the wave patterns (variations of wave height with time) to their basic physical characteristics.

The periodogram analyses of ocean wave records have resulted in claims of bewildering combinations of frequencies making up single patterns. It is suggested that usual methods of periodogram analyses are inadequate for this purpose in that they do not reveal the physical characteristics of the situation.

Consideration of the relationship between the wave spectrum and its autocorrelation function, from the viewpoint of generalized harmonic analysis, provides a more realistic and simplified approach to the evaluation of ocean wave data. This method, new to oceanographic analyses, describes the physical properties of the data, and may be employed in discovering their physical causes. The autocorrelation function gives all the information that can be obtained from an ordinary periodogram analysis and such additional information as obtained by the power of all frequencies considered continuously.

Analyses of more than 30 ocean wave records scattered over the North Atlantic have revealed that in every case the wave pattern was reduced to a cyclical component on which were superimposed damped oscillatory and random components. Periods and amplitudes are readily computed which, together with varying relationships between the components, characterize the physical properties of the wave patterns.

The geophysical interpretation of results is that in sea surface roughness patterns the cyclical component is predictable, and appears to be generated by the influence of a dominating oceanic meteorological situation over the ocean. The oscillatory and random components result

from the effects of local winds and other local disturbances tending to change basic ocean wave pattern.

Earthquakes and Rock Creep

Hugo Benioff, *Seismological Laboratory, California Institute of Technology*

(Introduced by Beno Gutenberg)

A method, based upon the modified instrumental magnitude scale of Gutenberg and Richter, is developed for determining the elastic rebound strain increments associated with earthquakes of a particular fault system. It is shown that a graph of the accumulated increments plotted against time for a given sequence of aftershocks or earthquakes represents the creep behavior of the fault rock.

Application of this method to the study of a number of aftershock sequences indicates that aftershocks are produced by the elastic afterworking or creep recovery of the strained fault rock. In some sequences the recovery assumes a dual form in which the first phase represents compressional afterworking and the second phase shear afterworking. Applied to earthquake sequences, the method provides a new means of observing tectonic processes in action. Movements corresponding to constant flow, exponentially increasing flow, and strain hardening creep are observed in different sequences and at all seismic focal depths. Evidence is offered to show that the South American and Tonga deep sequences represent single mechanical fault structures with linear dimensions of 4500 km and 2500 km respectively, and that the oceanic deeps associated with these structures are surface expressions of these great faults.

Early Tertiary Ecotones in Western North America

Ralph W. Chaney, *University of California*

The fossil plant record gives little support for the idea that climates have been uniform across many degrees of latitude in past ages. Far from being cosmopolitan, the floras of the Tertiary period show marked zoning; in western North America there was temperate vegetation in Alaska during the early part of the period, and subtropical forests occupied middle latitudes as far north as Washington and Wyoming. Between these zones there developed ecotones containing some of the more hardy southern plants, and many trees typical of higher latitudes. The dominant conifer was Metasequoia, a deciduous redwood once widely distributed over the northern hemisphere, and now known to live only in central China. The modern Metasequoia forest stands in ecotonal relationship to the subtropical forest of the lowlands in which broad-leafed evergreens predominate, and to the temperate forest of the uplands in which broad-leafed deciduous trees are most common. The survival of this mixed forest, whose observed members include most of the genera associated with Metasequoia tens of millions of years ago, represents an outstanding case of continuity, and provides an accurate basis for reconstructing Tertiary environments over wide areas in ages past.

The Spherical Sections of a General Surface

Edward Kasner, *Columbia University*

The plane sections of a surface S form a triply infinite family of curves. The spherical sections form a quadruply infinite family. When these curves are mapped on a plane, the differential equation is of the fundamental type

$$y^{1111} = Ay^{111^2} + By^{111} + C$$

which occurs in many dynamical problems and in the calculus of variations. The infinity of curves passing through a given point in a given direction have the property that the centers of the osculating conics themselves lie on a conic. The spherical curves of S may be regarded as another analogue of circles (in contrast to the standard definitions of Gauss and Minding).

All fields of force whose trajectories are plane curves were found by Halphen. The analogous problem for spherical trajectories is solved in the present paper.

Homotopy Groups of Certain Algebraic Systems

Paul A. Smith, *Columbia University*

Let Y be a groupoid in which there is singled out a subset Z of elements satisfying certain conditions. We define certain groups $p_n(Y, Z)$ determined by Y and Z. The groups p_1 and p_2 can be identified as first and second homotopy groups when the elements of Y and Z are suitably interpreted. Other interpretations lead to new results in the theory of abstract local groups and their extensions. In this direction we are led for example to a new proof of the existence of Lie groups in the large.

Production of Mesons by X-Rays

Edwin M. McMillan and Jack M. Peterson
University of California

The first experimental program to be undertaken with the Berkeley synchrotron is a study of meson production. The emergent beam of 335-Mev X-rays passes through a stack of nuclear plates (Ilford F-3), or through a slab of matter in the vicinity of such plates; then meson tracks in the emulsion are sought by microscopic examination. The results prove conclusively that mesons are produced, and that they are not the result of secondary heavy particles and most probably not the result of secondary electrons. A very rough estimate of the cross section for meson production by X-rays in glass is 3×10^{-30} cm^2 per nucleon. The number of quanta is here defined as the

total X-ray energy divided by the peak quantum energy. Since only mesons with energies below about 20 Mev will stop in the stack of plates and be counted, the actual cross section may be considerably larger.

Out of a total of 145 tracks recorded, 91 end in stars. Assuming that three quarters of all negative π mesons produce stars, and that every positive π meson is accompanied by a μ, this leads to a ratio negative π/positive $\pi \sim 10$. The actual π–μ decay is not always discernible on these rather insensitive plates; only five cases have been seen. The statistics given above include mesons from both glass and carbon, and in both cases the excess of negatives is apparent.

This work was done under the auspices of the Atomic Energy Commission.

Neutron-Proton Interaction

A. A. Broyles and M. H. Hull

*Yale University**

(Introduced by Gregory Breit)

The work of Rarita and Schwinger, while successful in accounting for the experimental value of the quadrupole moment of the deuteron, reduces the central field part of the potential by roughly 30 percent and implies a thorough revision of the nuclear binding energy calculations of Wigner, Feenberg, and others. In view of the probability from Breit's relativistic arguments that at least part of the tensor interaction does not have the same location in space as the central force, and the possibility noticed by Breit of obtaining closed solutions by confining the tensor potential to an infinitely thin spherical shell, the problem was reinvestigated. It was found that the quadrupole moment can be accounted for by placing the shell beyond $r_1 = 7\ e^2/mc^2$ from the center of force and that for $r_1 = 1.5\ e^2/mc^2$ the central field need be decreased by only about 2 percent. The triplet cross section at zero energy changes from 4.40 to 4.46 barns as r_1 changes from 1 to 1.5 (e^2/mc^2) while the central field square well range is $r_0 = e^2/mc^2$ and from 3.95 to 3.62 barns for $r_0 = e^2/2\ mc^2$. These effects are small and there remains the possibility of leaving the central field relatively unaffected by the addition of the tensor force. This work is related and is in general agreement with that of Guindon but deals with more pronounced effects.

Electromagnetic Induction in a Superconductor

W. V. Houston and C. F. Squire, *The Rice Institute*

No completely satisfactory atomic theory of superconductivity has been devised and it is important to investigate the phenomenon in various ways to be sure that even its macroscopic description is correct.

The law of electromagnetic induction can be illustrated with a Faraday disk. This is a conducting disk rotating in a magnetic field parallel to its axis. By means of sliding contacts near the axis and at the rim, the induced electromotive force can be observed.

To investigate the induction in a superconductor, a Faraday disk was built of lead, in the form of a flattened spheroid. It was mounted to be operated in a cryostat and the induced electromotive force was observed above and below the transition temperature of the lead.

It might be expected that no electromotive force would be produced below the transition temperature. In the first place a potential difference is not expected to exist across a superconductor. More convincing still is the fact that the magnetic flux does not pass through the superconductor, but is forced to go around the disk. Nevertheless the experiment showed almost no difference between the electromotive forces above and below the transition temperature. The small observed difference can easily be attributed to the experimental arrangement.

Although this result is somewhat surprising, it is consistent with observations reported by K. Onnes in 1924, which showed that a persistent current in a lead sphere could not be rotated into a different plane by means of a magnetic field.

Lorentz-Type Transformations as Derived from Performable Rod and Clock Operations

Herbert E. Ives, *Upper Montclair, New Jersey*

The Lorentz transformations are mathematical formulae calculated to leave the electromagnetic equations unchanged in form in relatively moving systems. In them the "local time" figures as a necessary substitution; the operations for establishing it were not developed. Einstein, while emphasizing the importance of performable operations, nevertheless bases his development on a *definition*, which requires that the measured time of transit of a light signal *sent in one direction* shall be half that of a signal *sent out and back*. The latter operation (the usual method of measuring the velocity of light) requires *one* clock, at the origin, the former *two* clocks, and the method of setting the second clock is the fundamental problem if Einstein's definition is to be replaced by a physical operation.

The problem is solved by using a "setting clock" which is moved at an observed velocity to the distant point, the "time" being determined by the setting clock itself. What the setting clock reading will be is derived from the contractions of length and clock rate as postulated by Fitzgerald and Larmor, and, in the case of clock rate, established by experiments on canal rays. The resulting transformations contain terms involving the observed setting clock velocity. The velocity of light, as measured by signals sent in one direction, is not, as by Einstein's definition, the same as for out and back signals, but is a function of the setting clock velocity. When the setting clock velocity is negligibly small the relations become the original Lorentz transformations.

* Assisted by joint program of the Office of Naval Research and the Atomic Energy Commission.

Duration of Phosphorescence of Metal Organic Complexes

S. I. Weissman and Philip H. Yuster

Washington University

(Introduced by Arthur H. Compton)

The coordination compounds of dibenzoyl methane with various metal ions exhibit photoluminescence of long duration. Although the spectral nature of this luminescence is almost independent of the metal ion, its duration is markedly dependent on the nature of the ion. The experimental observations are interpreted through G. N. Lewis's identification of phosphorescence as a transition between states containing different numbers of unpaired electrons. The probability of such a transition is sensitive to small departures from perfect pairing or from complete unpairing of electrons in the various states of a molecule. These departures result from spin-orbit interaction, i.e., interactions of electronic spins which are dependent on the positions of electrons.

Such interactions in the series of compounds here discussed arise from the motion of the electrons of the organic complexing agent through the electric fields of the nuclei of the metal ions, and from motion of the electrons in the inhomogeneous magnetic fields of paramagnetic ions. The effect of an inhomogeneous magnetic field is demonstrated by a fiftyfold decrease in duration of the phosphorescence of the complex with the paramagnetic gadolinium ion over the duration of the phosphorescence of the complex with the chemically similar but nonmagnetic lutecium ion. The effect of nuclear charge is shown by a tenfold decrease in duration of the phosphorescence of the lanthanum ($Z = 57$) compound over the aluminum ($Z = 13$) compound.

The results indicate that small departures from perfect pairing and unpairing of electrons in organic molecules, although they produce only insignificant effects on the energies of the molecules, are decisive in determining rates of certain photoprocesses.

A New Method for Measuring the Limiting Negative Pressure in Liquids

Lyman J. Briggs, *National Bureau of Standards*

In this method the liquid under examination is held in a capillary tube *open at both ends.* About one centimeter from each end the tube is bent back upon itself through an angle of 140° to form a Z. The tube is cemented symmetrically to a horizontal spinner mounted on the upper end of the vertical shaft of a high speed motor. It spins in its Z-plane with its *center intersecting the projected spin axis.* Consequently the liquid column at this point is visible even at high angular speeds. The breaking of the column is signalized by a marked change in the refraction of the tube.

In the centrifugal field, one half of the liquid column is pulling against the other. The maximum stress is at the center. The effective length of either half is the distance from the spin axis to the meniscus in the bent leg of the tube. If these distances are not equal when the motor starts, one meniscus immediately retreats and the other advances until equilibrium is restored.

The open-ended tube possesses the great advantage of being easy to clean and fill. Scrupulous cleanliness is necessary in measuring negative pressure. To facilitate filling, the open ends project slightly beyond the side of the supporting spinner. Use of a capillary tube also reduces to a minimum the solid surface in contact with the liquid and reduces the effect of vibration. Measurements are made under an absolute pressure of 3 or 4 cm Hg.

Preliminary measurements indicate that the limiting negative pressure of water as determined by this method is 223 ± 5 negative atmospheres at 27° C. This is equivalent to a vertical column of water 7400 ft high hanging from the closed top of the tube which contains it.

Thermoluminescence as a Research Tool

Farrington Daniels, Charles A. Boyd, and Donald F. Saunders

University of Wisconsin

Light may be emitted when a crystal is exposed to X-rays and heated gradually. Its intensity increases and decreases, giving peaks in an intensity-temperature curve, which correspond to different activation energies for trapped electrons. The characteristic curves can be used in studying the nature of the crystal and its previous history, its chemical impurities, its physical imperfections, and the kinetics of the release of stored energy. They are helpful also in comparing crystalline material from different sources, in correlating lattice distortions produced by mixtures as in the case of NaCl and NaBr, and possibly in evaluating the expected behavior of heterogeneous catalysts.

Many igneous rocks, limestones, and other minerals exhibit thermoluminescence due to radioactivity from traces of uranium or thorium. Even less than one part per million, with an accumulative effect over millions of years, may give a more sensitive test for radioactivity than a Geiger-Mueller counter. After being once heated the minerals lose their thermoluminescence, but brief exposure to X-rays restores this property. Uranium content, age, impurities, and imperfections are some of the factors in the thermoluminescence which are now being studied.

Some of the energy of radioactivity in rocks is dissipated as heat and carried away by conduction, but part can be stored as potential energy of displaced electrons (and atoms). After the latent traps are filled the temperature rises and the stored, potential energy can be released quickly in a manner similar to that observed in thermoluminescence. This hypothesis of rhythmic heating may have implications in geology.

The New Particles of Matter

Carl D. Anderson, *California Institute of Technology*

Some of the properties of the elementary particles of matter were discussed briefly, with emphasis on the results of recent studies of mesons. Reference was made to the phenomena concerned with the production and annihilation of μ and π mesons. The results of recent experiments in cosmic rays which show that the μ meson disintegrates into an electron and two neutrinos were presented. The bearing that these results have on the mass and spin of the μ meson was discussed.

The Study of an Iodide-Iodine Complex by Means of the Electromotive Force Centrifuge

Duncan A. MacInnes
Rockefeller Institute for Medical Research

B. Roger Ray, *University of Illinois*

The potential E of a galvanic cell consisting of two iodide-iodine electrodes at different radii in a centrifugal field was measured at a series of rates of rotation n. It was found that, when disturbing influences were eliminated, the ratio E/n^2 was accurately constant in each experiment. A series of determinations were made in which the solution in the cell was potassium iodide with varying proportions of iodine. The results indicated that the usual equation relating the potential E to the transference number, the radii, the molecular weights, etc., is correct only in the limit of zero concentration of iodine. For finite concentrations of iodine the equation must be modified to include the effect of an iodide-iodine complex on the mechanism of the cell. The measurements are in complete quantitative accord with a complex of the composition I_3^-. The results also yield values of the transference number of potassium iodide in close agreement with determinations by the moving boundary method.

Individual Metabolic Patterns, Alcoholism; Genetotrophic Diseases

Roger J. Williams, L. Joe Berry, and Ernest Beerstecher, Jr.
University of Texas

Distinctive metabolic patterns in individuals are probably due to commonplace partial genetic blocks which give rise to augmented requirements for specific nutrients and hence to altered metabolisms.

Rats and mice with diverse genetic backgrounds exhibit individual responses with respect to alcohol consumption. Some abstain indefinitely, some consume moderately, some are irregular, others steady. Some animals consume relatively heavily beginning the first day, others do so only after several weeks. These responses are genetically controlled; animals with the same genetic background exhibit uniform responses.

Alcoholic consumption in all these animals can be raised ultimately to a high level or reduced to nearly zero, depending on whether or not their nutritional needs are completely met. The alcoholic consumption of certain strains of animals and certain individual specimens is relatively difficult to reduce. Clear evidence is presented that diverse deficiencies in different animals are responsible for the creation of an appetite for alcohol.

These findings suggest the broader concept of genetotrophic (geneto = genetic; trophic = nutritional) diseases of which alcoholism is thought to be one. On the basis of genetic variations one individual may suffer from nutritional disease on a diet wholly satisfactory for others. The possibility that genetotrophic factors are operative in numerous diseases of obscure etiology, e.g., allergies, mental diseases, cardiovascular diseases, arthritis, multiple sclerosis, drug addiction, and even cancer, requires exploration.

Psychological and social influences doubtless play a role in alcoholism and in "mental diseases" generally, but an investigation of biochemical factors demands far more emphasis than it has received.

On the Central Zone of the Human Fovea

Walter R. Miles
Yale University School of Medicine

An observer's attention may be directed to perceptual material presented at any part of the visual field. But it is relatively easier to pay attention to central rather than to far peripheral areas. Our usual experience seems to indicate radiating gradients of decreasing psychological clearness extending from the point of fixation in all directions on the visual plane. Under optimal illumination we see best, quickest, and with most satisfaction visual images formed on the fovea immediately around the point of fixation. Our eyes are highly mobile and ordinarily turn appropriately to bring interesting visual material into "full gaze" on the fovea. The receptor elements (cones) in this region are highly sensitive to fine detail and color, and the region is spoken of as the "rod-free" area. The over-all diameter of this nearly circular spot, the fovea, is commonly given as from 3° to 5°.

Concentric zonation within the fovea itself may be demonstrated and plotted by the use of special filters and a technique which we have previously reported. In normal eyes it is characteristic to find a central disc area about 30′ in diameter which in certain ways seems functionally distinct from immediately surrounding areas. In our experimental findings the subject's fixation point always falls within this disc, which comprises a relatively small population of elongated cones. Usually fixation falls very close to the center of the foveal disc. Results are reported on the location and variation of the positions of the fixation points for pairs of eyes in a sample adult population, and on the relation of positive scotoma to fixation position. Implications of fixation of the line of

regard near the center of a "favored" group of specialized optic nerve endings are suggested.

The Cortical Correlate of Pattern Vision

Wolfgang Köhler and Richard Held

Swarthmore College

During recent years, the question has arisen whether the activities of the human brain are throughout of the same kind as the events which are known to occur in peripheral parts of the nervous system, namely, nerve impulses. Both psychological and physiological evidence has been accumulating according to which functional interrelations in the brain are partly mediated by a continuous field action. Moreover, from the investigation of certain facts in visual perception it has been inferred that this field action consists of direct currents which spread through the brain as a continuum. This thesis has been subjected to direct physiological tests by the authors, and has been found to be correct. The currents can be registered from the intact heads of human subjects. The behavior of the currents agrees with available knowledge about the anatomy of the visual cortex and with predictions from biophysical theory. Rival interpretations of the results have so far been refuted. The authors do not suggest that their observations are at odds with more familiar facts in neurophysiology. On the contrary, they are convinced that the new facts are directly related to the arrival of nerve impulses in the brain. They point out, however, that psychological experience and cortical events are likely to be much more sensibly connected if brain action is mainly a matter of field physics than they would be if brain action consisted only of nerve impulses.

The Developmental Aspect of Child Vision

Arnold Gesell, *Yale University*

Under a cooperative program of research over a period of 10 years, the Yale Clinic of Child Development has made periodic studies of the visual functions of normal infants and children of preschool and school age. These studies are concerned with the progressive organization of visual functions in their relationship to the action system of the growing child at a score of age levels. Five functional fields have been explored in a preliminary manner: 1) eye-hand coordination; 2) postural orientation; 3) fixation; 4) projection; 5) retinal reactions. The data were gathered by means of developmental examinations of behavior patterns; naturalistic observation of spontaneous and adaptive behavior at home, school, and guidance nursery; graded tests of visual skills; optometric tests; and examinations by streak retinoscope (without cycloplegia).

The retinoscopic findings in conjunction with other findings indicate that the visual mechanism is in a somewhat labile condition, both dynamically and developmentally. Superimposed upon a basic delimiting refractive state there is a margin of adaptability which is manifested in the brightness, the motion, the direction, and the speed of the retinal reflex. Developmental stages can be differentiated according to the child's visual manipulation of space.

The visual system and the unitary action system prove to be intimately and reciprocally related. The child sees with his total makeup. Acuity is only one aspect of the economy of vision. From the standpoint of a developmental optics, visual functions can be interpreted in terms of their dynamic relation to the maturity and operations of the basic action system. This has implications for visual hygiene. Eye care involves child care.

Audition—A Physiological Survey

Hallowell Davis

Central Institute for the Deaf, St. Louis, Missouri

An important trend in the study of audition is the coordination of many points of view, from engineering through biophysics and physiology to psychology. Increasing attention is being directed to the problem of transmission of information. This orientation yields a common frame of reference.

The physical action of the ear as an analyzer of sound is now fairly well understood, and the place principle of pitch perception is generally accepted with minor reservations. In the nervous system the all-or-none principle of nerve action defines the physiological code of transmission, i.e., a dot-dot-dot system of signals at various rates over thousands of parallel conductors. The gap between nerve impulses and consciousness, however, is as wide as ever.

An unsolved problem in the biophysics of audition is the mechanism of excitation of nerve impulses in the sense organ. The attractive theory of electrical stimulation by the aural microphonic (an electrical effect generated in the sense organ by sound) requires additional hypotheses to reconcile it with some of our recent observations. In neurophysiology also special hypotheses are required to explain the great ability of the ear to discriminate differences in the pitch and also in the loudness of sounds. A possible explanation may be that subsystems of nerve fibers and perhaps sensory cells as well may be specialized separately for such discriminations. The more refined discriminations of pitch and intensity require more time than simple detection of a signal. This suggests more complicated interactions between nervous pathways within the nervous system. The kind of specialization that we suggest seems particularly probable for the fine discrimination of time differences between similar signals reaching the two ears. It is on these small time differences that much of our ability to identify the direction of the source of sounds depends.

The Effect of Protein Depletion on Acquired Immunity in Trichinosis

William H. Taliaferro, Robert L. Woolridge, and Earl P. Benditt

University of Chicago

Prolonged protein depletion in rats has been shown to lower immunity to trichinosis acquired on adequate diets. The two antibodies described by Oliver-González as being active against adult worms in the intestine and larvae in the muscles were differentially affected. A low protein diet for seven days prior to and continued during infection reduced the antilarval antibody but not the antiadult antibody. A similar low protein diet started 33 or more days before infection reduced both antibodies, and the adults were not expelled from the intestine as effectively. This differential action on the antibodies by the seven-day preliminary depletion can be correlated with the fact that adults liberate antigen before protein depletion is marked, whereas larvae liberate antigen later, after protein depletion has become pronounced.

Histological studies indicated that trichinosis resulted in a marked hyperplasia of the spleen and mesenteric lymph nodes which was less marked in the animals depleted 10 weeks prior to and during infection. The worm larvae in depleted as contrasted with the adequately fed animals were associated with smaller mononuclear accumulations and fewer eosinophils on the average. These differences in inflammatory response are probably due to the lower antibody response in the depleted animals.

The State in Nature of the Active Principle in Pernicious Anemia * of Catalase, and of Other Components of Liver†

Edwin J. Cohn, Douglas M. Surgenor, Richard W. Greene, Margaret Hunter, F. W. Kahnt, and others‡

Harvard Medical School

The outstanding result of our study of the components of blood was the observation that few of the nonprotein constituents were free, and many were in very specific if more or less labile combination with one or another plasma protein. This suggested that nonprotein, and many protein, constituents exist in tissues in combination with proteins.

Nitrogenous constituents of the body have generally been extracted by procedures which allowed chemical or enzymatic dissociation of natural complexes and have been investigated following protein denaturation. The fractionation and crystallization of proteins in alcohol-water mixtures at subzero temperatures have yielded a series of plasma components more nearly in the state in which they exist in nature.

In liver, an organ with many components in equilibrium with plasma, the active principle effective in pernicious anemia has been extracted and reprecipitated in combination with a protein fraction. Catalase has been separated in another fraction in combination with another protein from which it is readily split and crystallized as the free protein. Still other fractions contain the desoxy- and ribonucleoproteins and the various enzymes of liver.

These investigations open the way for the study of the histological locus of the component in the tissue and of the mechanism of release from the tissue.

* Clinical assay has been carried out with the collaboration of a committee of the Hematology Study Section, National Institutes of Health, Bethesda.

† Large scale fractionation of liver has been carried out with the collaboration of Drs. Jules D. Porsche and James B. Lesh of the Armour Laboratories, Chicago.

‡ Including Bo Norberg, Sweden, in 1946–47; Gustave Derouaux, Belgium, and Hans Nitschmann, Switzerland, in 1947–48.

Sickle Cell Anemia, a Molecular Disease

Linus Pauling, Harvey A. Itano, S. J. Singer, and Ibert C. Wells

California Institute of Technology

The nature of the phenomenon of sickling of erythrocytes in sickle cell anemia suggests that this disease involves a pathological state of the hemoglobin molecule. The electrophoretic behavior of hemoglobin from individuals with sickle cell anemia and from normal individuals has been studied with the Tiselius apparatus. Both ferrohemoglobin and carbonmonoxyhemoglobin from sickle cell blood and from normal blood were studied in phosphate buffers of 0.01 ionic strength at pH values of 5.7, 7.0, and 8.0. A significant difference was found between the electrophoretic mobilities of hemoglobin derived from sickle cell blood and from normal blood. The curves of mobility against pH are roughly parallel, the iso-electric point of normal hemoglobin being lower than that of sickle cell hemoglobin for each compound. At pH 7.0 sickle cell carbonmonoxyhemoglobin moves as a positive ion while normal carbonmonoxyhemoglobin moves as a negative ion. The most plausible explanation for the observed difference in mobility is that there is a difference in the number of acidic or basic groups in the two hemoglobins, amounting to three or four such groups per molecule. The existence of this difference in the nature of the hemoglobin suggests that the disease itself is a molecular disease, and that the change in shape of the erythrocytes leading to its symptoms is the result of the difference in the properties of the molecules. A possible mechanism for this phenomenon is proposed.

Enzymatic Studies of Cellular Organization

Berwind P. Kaufmann

Carnegie Institution of Washington

(Introduced by M. Demerec)

In an approach to problems of the nature and specificity of action of genes in higher organisms, cytochemical

methods, utilizing carefully purified enzymes in combination with various staining procedures, were developed to determine the distribution and interrelations of nucleic acids and proteins in dividing cells of a series of plants and animals. Patterns of distribution were determined by exposing smears or sections of tissues, preserved in a variety of fixatives, to the selective action of purified enzymes—such as ribonuclease, desoxyribonuclease, and pepsin—that degrade specific materials without disrupting visible structural continuity. Patterns of association between nucleic acids and proteins were revealed by successive treatments with different enzymes, or enzymes and chemicals. Thus experiments using ribonuclease, pepsin, and trichloracetic acid independently and in combination revealed that much of the ribonucleic acid in fixed cells exists in association with nonhistone (tryptophane-containing) protein, and that there is in condensed chromosomes a type of ribonucleoprotein which increases and decreases in the cycle of mitosis and is presumably related to the control of genic activity. Similar experiments using desoxyribonuclease indicated that desoxyribonucleic acid is in part associated with the histone type of protein. These experiments also showed that the structural continuity of the chromosome is not destroyed by hydrolysis with desoxyribonuclease, ribonuclease, or pepsin. However, it is destroyed by hydrolysis with either chymotrypsin or trypsin, or by pepsin after removal of nucleic acids.

Sexual Behavior as a Function of Androgen Concentration

Frank A. Beach*

Yale University

(Introduced by Walter R. Miles)

It is well known that the reduction or loss of sexual capacity which usually follows castration in male animals can be prevented by administration of exogenous androgen. This fact has been established by experiments upon birds, reptiles, and mammals. Less systematic observations of hypogonadal patients indicate that in some cases androgen therapy occasions an increase in the erotic responsiveness and potency of human males. In no instance, however, have the behavioral effects of different dosages been carefully examined. This was attempted in the present study. Male rats were observed in a series of tests with receptive females before and after castration. Following the operation testosterone propionate was administered by daily injection, different concentrations being employed for five groups of animals. A control group received plain sesame oil and others were treated with 1 to 500 μg of hormone every 24 hr. Approximately 50 μg per day maintained mating behavior at preoperative levels. An equivalent daily dose for a 175-lb man would be approximately 13 mg of testosterone propionate. In rats receiving smaller amounts of hormone response to the female occurred less promptly. The frequency of intromissions and ejaculations was reduced and the rest periods following orgasm became longer. These animals showed symptoms usually associated with human hypogonadism. Administration of 100 or 500 μg of androgen per day produced a rise in the number of ejaculations occurring in a time-limited test, increased the speed with which mating was begun, and shortened the post-ejaculatory rest period.

* With the assistance of A. M. Holz-Tucker.

Inhibition of Plant Growth by Protoanemonin and Coumarin and Its Prevention by BAL

Kenneth V. Thimann and Walter D. Bonner, Jr.

Harvard University

It has been suggested in a previous paper that unsaturated lactones exert their growth-inhibiting effects on plants through reaction with a sulfhydryl enzyme. This enzyme is evidently a limiting factor in the growth of isolated sections of oat coleoptile or pea stem and is responsible for growth inhibition by iodoacetate, arsenite, and organic mercurials. In the present paper it is shown that coumarin and protoanemonin inhibit both straight and curved growth, the protoanemonin being 10 to 30 times the more active. At subinhibiting concentrations the growth is promoted in each case. The inhibition is clearly prevented by the addition of dimercaptopropanol, BAL, at concentrations below 3.10^{-4} molal.

It is concluded that coumarin and protoanemonin do inhibit growth by reacting with sulfhydryl enzyme, and that this enzyme is probably the same as that inhibited by iodoacetate and arsenite.

New Evidence on the Origin and Evolution of Maize

Paul C. Mangelsdorf

Botanical Museum, Harvard University

Remains of maize isolated from a cultural deposit in New Mexico and estimated to represent a span of approximately 3,000 years, beginning several millenia B.C., have thrown new light on the problem of the origin and evolution of maize. They show that primitive maize was both a pop corn and a pod corn bearing small corneous kernels enclosed in glumes. The husks which in modern maize completely surround the ear were present in primitive maize but did not yet enclose the ear. There was a progressive increase in average cob and kernel size during the period represented by the remains and a tremendous increase in the total range of variation. The accumulation of variation appears to be one of the most important factors involved in the evolution of plants and animals under domestication and may prove to have an important bearing upon evolutionary processes in nature.