the precursor is utilized and the corresponding penicillin formed. For example, addition of N-(2-hydroxyethyl)-phenoxyacetamide to the culture medium did not appreciably increase the total units of penicillin activity produced, but a high percentage of the penicillin was isolated in a single fraction which was shown to be the new phenoxymethylpenicillin.

A large number of compounds were prepared and tested as possible precursors of new penicillins, and in several cases the new penicillins were isolated in analytically pure, crystalline form (Table 2). Each of the new penicillins listed, except numbers 2, 8, and 11, gave satisfactory analytical values and was further identified by the ultraviolet absorption curve in comparison with that of the precursor used. The three exceptions, p-nitro-benzylpenicillin, p-iodobenzylpenicillin, and p-tolylmer-captomethylpenicillin, were obtained in a somewhat impure state, but the presence of these new penicillins was demonstrated by examination of their ultraviolet absorption spectra. It will be noted that p-bromobenzyl-penicillin was isolated after the use of N-(γ-p-bromo-phenylbutyryl)-DL-valine. Examples of terminally phenyl-substituted butyl and butyryl compounds that have been used as benzylpenicillin precursors are given in Table 1. It is apparent that substituted butyric acid derivatives are effective in a manner similar to the corresponding substituted acetic acid derivatives.

Attempts to find precursors for the three-carbon moiety or the penicillamine portion of the penicillin molecule have been unsuccessful.

The following groups have participated in the joint program for the chemical study of penicillin and have contributed to various aspects of the precursor work: In Britain, British Drug Houses, Ltd.; Glaxo Laboratories, Ltd.; Imperial Chemical Industries, Ltd.; Imperial College of Science, London, Department of Organic Chemistry; and Oxford University, Department of Crystallography; in the United States, Abbott Laboratories; U. S. Department of Agriculture, Northern Regional Research Laboratory; Cutter Laboratories; Heyden Chemical Corporation; Eli Lilly and Company; Merck and Co., Inc.; and The Upjohn Company.

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The National Academy of Sciences:
Abstracts of Papers Presented at 1947 Autumn Meeting

Growth of Particles in Smokes and Clouds and the Production of Snow From Supercooled Clouds

Irving Langmuir

General Electric Company

V. J. Schaefer introduced pellets of dry ice into clouds of supercooled water droplets and produced enormous numbers of minute ice crystals which rapidly grew into snowflakes. B. Vonnegut found that silver iodide vaporized into air can give nuclei which induce the formation of snowflakes in supercooled clouds below −5° C. Account is given of the development of these ideas from studies made during the war of fundamental aspects of: (1) gas mask filters; (2) smokes needed for screening purposes; (3) the radio interference caused by the electric charging of aircraft flying through snow; and (4) the icing of aircraft when flying through supercooled clouds. A theory of the growth of particles in aerosols has served as a guide in these various researches. The experiments in progress during the last year on the artificial production of rain and snow, now Project Cirrus with the Signal Corps and the Navy, have led to many interesting results which are described and explained. The generation and wartime use of screening smokes and the effects produced by the seeding of stratus and cumulus clouds are illustrated. A preliminary account of the flight tests over the recent hurricane of October 10–15 is given.

Physical Families of Curves

Edward Kasner

Columbia University

In any field of force the most important curves are the trajectories (paths of possible motion). Thus, for the Newtonian field we have the planetary orbits, the conic sections of Kepler. Another important physical family is formed by the generalized catenaries, forms of equilibrium of a suspended chain. Other physical families in the field are brachistochrones and velocity curves.

Analogues and differences between these families are explored. The number of parameters (degrees of freedom) is always the same (three for the plane, five for space). The focal locus is always circular, but the position of the focal circle varies. The locus of the centers of all the circles is found. The fundamental theorem about starting from rest (ratio of curvatures is one-third) is generalized.

Relativistic Wave Equations

Eugene P. Wigner
Princeton University

Recent work by Gelfand and Newmark (*J. Phys. USSR*, 1946, **10**, 93; cf. also V. Bargmann. *Ann. Math.*, 1947, **48**, 568) and of L. Garding (personal communication) has established that infinitesimal operators in the usual sense can be defined also for representations of open groups. The representations of the inhomogeneous Lorentz group which have been obtained previously (*Ann. Math.*, 1939, **40**, 149) by the consideration of finite transformations must also be obtainable, therefore, by considering the infinitesimal operators.

The most important combinations of infinitesimal operators which commute with all infinitesimal operators are $\mu = p_4^2 - p_1^2 - p_2^2 - p_3^2$ and $\nu = w_1^2 + w_2^2 + w_3^2 - w_4^2$, where $w_1 = M_{23}p_4 + M_{34}p_2 + M_{42}p_3$, etc., and the p and M are the infinitesimal operators of displacement and of space-time rotations, respectively. Both μ and ν assume a definite numerical value in an irreducible representation. If $\mu > 0$, one is led, as is well known, to the linear manifolds of the particles with finite mass and spins $0, \frac{1}{2}, 1, \ldots$ etc. If, however, $\mu = 0$, the remaining ν alone does not permit characterization of the linear manifolds. In particular, from $\mu = 0$, $\nu = 0$, the vanishing of all 6 expressions $p_j w_k - p_k w_j$ follows, and this makes it possible to define a scalar s by stipulating that $w_j \pm isp_j$ vanish also. This discussion shows that, in some cases, the consideration of the finite operators affords a more powerful tool for the determination of the irreducible representations than the use of the infinitesimal operators only.

The manifolds with $\mu = 0$, $\nu = 0$ are well known to characterize particles with zero rest mass and spins $s = 0, \frac{1}{2}, 1, \ldots$ etc. Manifolds which were not discussed before are obtained by setting μ zero but keeping ν finite. These manifolds can be characterized by the equations

$$(p_4^2 - p_1^2 - p_2^2 - p_3^2)\psi = 0 \tag{1}$$

$$(\xi_1 p_1 + \xi_2 p_2 + \xi_3 p_3 - \xi_4 p_4)\psi = 0 \tag{2}$$

$$(\xi_1 2 + \xi_2 2 + \xi_3 2 - \xi_4 2 - 1)\psi = 0 \tag{3}$$

$$\left(p_1 \frac{2}{\partial \xi_1} + p_2 \frac{2}{\partial \xi_2} + p_3 \frac{2}{\partial \xi_3} + p_4 \frac{2}{\partial \xi_4} - i \, \Xi \right)\psi = 0. \tag{4}$$

The ψ can be thought of as depending on the 8 variables x_1, x_2, x_3, x_4, ξ_1, ξ_2, ξ_3, ξ_4. The p then must be replaced by the corresponding $\partial/\partial\chi$. The infinitesimal operators of space-time rotations assume the form $M_{12} = x_1\partial/\partial x_2 - x_2\partial/\partial x_1 + \xi_1\partial/\partial\xi_2 - \xi_2\partial/\partial\xi_1$, etc. The first two terms of the M do not give any contribution to the w. As a result, when calculating ν, one obtains

$$\nu = \Sigma m_{ik}^2 \mu - \Sigma(m_{ik}m_{k1} + m_{k1}m_{ik})p_i p_c, \tag{5}$$

where the $m_{12} = \xi_1\partial/\partial\xi_2 - \xi_2\partial/\partial\xi_1$, etc. commute with the p. The first sum vanishes because of (1); the second can be evaluated by means of (2), (3), (4) to be equal to Ξ^2. This shows that the above set of equations actually corresponds to the case $\mu = 0$, $\nu = \Xi^2$.

Solar Activity as the Origin of Cosmic Rays

Donald H. Menzel and Winfield W. Salisbury
Harvard University
(Introduced by Harlow Shapley)

Magnetic fields of sunspots may exhibit random fluctuations of the order of from 1 to 30 gauss. These variations are associated with the gustiness and turbulence of the solar atmosphere. As one consequence of these fluctuations, the sun will emit radio noise the frequencies of which range from perhaps 2 cycles/minute to 1,000 cycles/second. Because of the long wave lengths, the radiation can escape from the sun, especially in regions where magnetic fields reduce the conductivity. The energy also can penetrate the ionosphere of the earth. Observations made with a loop antenna and audio-frequency amplifier indicate that oscillations of this type do occur on the earth's surface.

Magnetic fields limit the energy that a charged particle can assume, the light electrons being more inhibited than the heavier ions. In space, within a few million miles of the earth, heavier ions may attain energies as great as 10^{11} volts. It is suggested that cosmic rays result from such action. Cosmic-ray showers are explained as arising from a local cloud of ions and not as secondaries from a single particle. The neutron component comes from the splitting of heavier atoms into neutron-proton constituents as they encounter the earth's atmosphere.

The theory outlined above makes cosmic rays a local phenomenon. The radio waves responsible for the cosmic rays also produce other effects. They cause appreciable heating of the solar atmosphere and lead to the million-degree temperature of the solar corona. The emission exerts a cooling action on sunspots. The light of the night sky and aurora borealis are electrodeless discharges in the electric field of the radiation. Other effects include certain types of ionospheric disturbances and the existence of a potential gradient in the earth's atmosphere.

Initial Performance of a 32-Mev Proton Linear Accelerator

Luis W. Alvarez, Hugh Bradner, Hayden Gordon, Lauriston C. Marshall, Frank Oppenheimer, Wolfgang K. H. Panofsky, Chaim Richman, Robert Serber, Clarence Turner, and John R. Woodyard
Radiation Laboratory, University of California, Berkeley

A beam of 32-Mev protons has been produced by the accelerator. Four-Mev protons from a Van de Graaff generator are injected into a resonant cavity operating at about 200 megacycles and driven by 23 oscillators delivering a total of 1.5 megawatts peak power. The beam is phase stable and is focused radially by the action of grids of tungsten wires. Absorption measurements show the beam to have an energy of $32 \pm .5$ Mev, in agreement with that predicted from the mechanical design. This work was done under the auspices of the U. S. Atomic Energy Commission.

The Creep and Plastic Flow of Solid Materials

Henry Eyring
University of Utah

Stresses applied to solids cause elastic deformations accompanied by plastic flow. The latter may be permanent or may disappear after the stress is removed. Maxwell long ago formalized such an analysis by writing

$$\frac{ds}{dt} = \frac{1}{G}\frac{df}{dt} + \frac{1}{\eta}f, \tag{1}$$

where s, f, t, G, η are the strains, stress, time, Hooke's law constant, and viscosity, respectively. The supposed linear dependence of rate of strain, $\frac{ds}{dt}$, on the stress, f, is not true. Thus, in certain steels increasing $\frac{ds}{dt}$ by 1,000-fold only requires a 40 per cent increase in f, and in certain textile fibers an increase in $\frac{ds}{dt}$ by 25-fold only requires a change in f of 16 per cent.

In 1936 the author showed that if plastic flow is recognized as being a relaxation process, it must obey the statistical laws characterizing chemical reactions, and equation (1) becomes

$$\frac{ds}{dt} = \frac{1}{G}\frac{df}{dt} + r\left\{\frac{kT}{h}e^{-\frac{\Delta F^*}{kT}}\right\}\left(e^{\frac{f v_1}{kT}} - e^{-\frac{f v_2}{kT}}\right). \tag{2}$$

Here, r is dimensionless, and for tension becomes the ratio of the increase in length for each individual relaxation event divided by the distance between relaxing regions in the direction of extension; the bracketed expression is the usual expression for a rate of reaction; f is the applied force per unit area and, when multiplied by the volume V_1, gives the work done on the relaxing unit as it passes from the normal to the activated state; $f v_2$ is the extra work a unit reversing the relaxation must do against the applied force. When $f v_1$ and $f v_2$ are small compared with kT, equation (2) reduces to (1). In other cases, the exponential dependence of $\frac{ds}{dt}$ on f quantitatively explains the previously observed nonlinearity. For a symmetrical potential barrier, $V_1 = V_2$. This relaxation theory has been found extremely useful in explaining the observed plastic behavior of textiles, rubber, metals, and inorganic nonmetals. Some of these results are shown.

Equation (2) provides an explanation for some results reported by Bridgman in which large hydrostatic pressures greatly increase breaking strengths. Thus, the free energy of activation, ΔF^*, for any rate process can be written as

$$\Delta F^* = \Delta F_0^* + p\overline{\Delta V}.$$

Here, ΔF_0, which is the free energy of activation at zero pressure, is increased by the pressure multiplied into the mean volume of the hole, $\overline{\Delta V}$, required to permit the flow process. Thus, in (2), if $\overline{\Delta V}$ is about the size of V_2, it is clear that any increase in pressure will cause a corresponding increase in the stress per unit area, f, necessary to maintain a given rate of distortion. Pressure, by selectively slowing down the processes involving the larger holes, $\overline{\Delta V}$, changes the nature of the flow process. The effect of pressure in increasing breaking strength in particular is due to the slowing down of the individual rate processes involved in breaking.

So far as we are now able to see, all deformation problems are interpretable in terms of the individual relaxation processes which have been briefly sketched.

Viscosity, Sedimentation, and Diffusion of Polymers in Solution

P. Debye and Arthur M. Bueche
Cornell University

Staudinger suggested that the intrinsic viscosity of a polymer solution should be proportional to the molecular weight of the polymer molecule. In the course of time it has been shown that a rule stating proportionality with another power of the molecular weight (usually between 1 and $\frac{1}{2}$) represents the experimental facts much better. A similar behavior is found for the sedimentation and diffusion constants.

It seems important to investigate whether such relations are more than convenient interpolation formulae and, if it should turn out that they are not, to find which relations should be substituted. If such more fundamental relations can be found, it remains to be seen in which sense the customary power relations can be considered as an approximation and what the significance is of the numerical constants, entering in such relations, in terms of the molecular structure of the polymer molecule.

The polymer molecule is represented as a pearl string, with beads representing the monomer and freedom of motion of its links representing the more or less restricted freedom of rotation of the chemical bonds around each other. Such a model leads to Staudinger's original rule, provided it is assumed that the disturbance of the general flow in the liquid due to each bead dies out so rapidly with increasing distance that its effect on the flow around the other beads can be neglected. This, however, does not hold, and the situation is analogous to that of a dielectric in an electrical field, a case in which the electric moments of the different elements of volume of the dielectric create an additional field which has to be taken into account.

The mathematical problem of taking into account the interaction of the beads has been put in a simplified mathematical form. The flow is calculated around and through a spherical particle, the interior of which offers an added resistance to the flow proportional to the number of beads it contains per unit volume. The computed velocity distribution is used in order to calculate the intrinsic viscosity. This quantity now depends on (a) the volume of the sphere, (b) a number, which has been called the "shielding ratio," defined as the quotient of the radius of the sphere and a length, the "shielding length," which is proportional to the reciprocal of the square root of the bead density within the sphere. This length measures how far the effect of the outside velocity distribution reaches into the interior of the sphere.

Discussing the intrinsic viscosity as a function of the degree of polymerization of the polymer chain according to this theory, it is found that for short chains the intrinsic viscosity is proportional to the molecular weight. With increasing chain length this increase is retarded, and in the limit for very long chains the intrinsic viscosity becomes proportional to the square root of the molecular weight. Over a restricted region of molecular weights the curve can be approximated by a

power of the molecular weight between 1 and $\frac{1}{2}$. This exponent of the power rule is a measure for the shielding ratio. After this shielding ratio has been determined, measurements of the intrinsic viscosity can be used to determine the average space occupied by the polymer chain in the solvent. In the case of polystyrene, the size of this space calculated from viscosity compares favorably with the size determined by an interference method based on the observed angular dissymmetry of the light scattered by the solution.

Similar calculations for the sedimentation and diffusion constant have been made by A. M. Bueche. Again, the power rule is interpreted as an approximation and its exponent explained as an effect of the shielding.

Influence of Ultrasonic Irradiation Upon the Phase Transition in the Formation of Colloidal Sulfur

Victor K. La Mer and James W. Yates

Columbia University

When dilute sodium thiosulfate (0.0012M) and HCl (0.0024M) are mixed, the resulting solution remains crystal clear for a reproducible time of 47 ± 1 minutes. The reproducibility of this time appears to be independent of the source of the distilled water. Measurements (La Mer and Kenyon. *J. colloid Sci.*, 1947, **2**, 257; Johnson and La Mer. *J. Amer. chem. Soc.*, 1947, **69**, 1187) of the ultraviolet absorption (3,100 A.) in a Beckman Spectrophotometer show that molecularly dispersed sulfur is being continually produced at an accelerating rate until a critical limiting degree of supersaturation ($\sim 3.10^{-6}$ g atoms S/l.) is reached which can no longer be tolerated by the system. This time limit is signalized by the appearance of a Rayleigh type of Tyndall beam. It corresponds to a phase transition wherein the molecularly dispersed sulfur is converted into droplets of supercooled λ sulfur of a size sufficient to exhibit perceptible light scattering, in both the ultraviolet and the visible regions.

Attempts to alter the time of this phase transition by the addition of foreign nuclei, by redistillation of the water *in vacuo*, removal of dissolved gases by boiling, and increasing the content of nitrogen by shaking under 20 pounds of pressure, have proven thus far to be without significant effect.

In view of the well-known property of ultrasonic waves to relieve supersaturation (Sollner. *Chem. Revs.*, 1944, **34**, 388), irradiation of the reaction solutions was tried at 400 kilocycles. The results were startling. The normal time of 47 minutes was increased fourfold. More carefully planned experiments show that the effect is not due to the production of H_2O_2 or any detectable chemical change upon the reactants. In fact, the delay can be produced simply by irradiating the distilled water to which the proper amount of concentrated HCl and thiosulfate is added after the treatment. In these cases two to four minutes irradiation of distilled water delays the onset of the phase transition to 3–7 hours.

Preliminary measurements on the ultraviolet absorption show that the production of molecularly dispersed sulfur from the homogeneous reaction continues beyond the normal period of 47 minutes, resulting in a much higher ($\sim$5-fold) degree of supersaturation than exists at the normal time limit for the transition to colloidal sulfur.

It would appear that the ultrasonic radiation removes some unknown nuclei, presumably present in fairly constant number in distilled water, which normally play a role in the condensation process in the colloid formation. The normal phase transition is apparently not one of self-nucleation, as was formerly assumed.

When the initial concentrations of HCl and $Na_2S_2O_3$ are systematically varied, the normal timing of the transition is affected in a reproducible manner, the normal critical limiting supersaturation appears to be constant, but the number of particles formed, as judged by the light absorption as a function of wave length (Barnes and La Mer. *J. colloid Sci.*, 1946, **1**, 79; Barnes, Kenyon, Zaiser, and La Mer. *Ibid.*, 1947, **2**, 333), varies with the concentration.

When the irradiated water is divided into two aliquots, one of which is carefully protected from air and atmospheric dust and the other is not, the times were found to be roughly 7 and 3 hours, respectively. Experiments are in progress to test various hypotheses of the nature of the nucleation process.

Recent Experiments With the 184-Inch Cyclotron

R. L. Thorton

University of California

(Introduced by E. O. Lawrence)

Study of disintegrations and other nuclear processes involving nuclear projectiles of energies in the neighborhood of several hundred million electron volts will yield important information about the structure of the nucleus, and many laboratories here and abroad are building or planning equipment to reach these energies. The 184-inch cyclotron of the Radiation Laboratory has now been in operation for about one year and provides deuteron and alpha-particle beams of 190 and 380 Mev, respectively. When the deuteron beam strikes any target, splitting of the deuterons yields, in addition, neutrons and protons of energies centering about 90 Mev and emitted in a narrow cone about the deuteron direction. Many experiments have been carried out using these radiations. The results of some of these, and their significance, are discussed.

When these fast particles are incident upon a nucleus, the disintegrations are often more complex than those found at lower energies and frequently result in the ejection of many neutrons, protons, and alpha particles. In addition, fission is produced among many of the heavier elements and has been observed for atomic numbers as low as tantalum. (Such fission produced by very high-speed particles has, of course, no immediate application in the utilization of atomic energy.) Such nuclear events are observed in the cloud chamber and photographic emulsions as well as being deduced from a study of the radioactive isotopes produced.

Other experiments have indicated that nuclei, especially the lighter ones, are partially transparent to very fast particles. Thus, a fast neutron is apparently able to pass through a nucleus with the loss of only a fraction of its incident energy. Experiments indicating this are measurement of total neutron cross-sections and excitation curves for certain nuclear reactions involving light elements.

Evidence of exchange reactions, whereby a fast neutron entering a nucleus will exchange identity with a nuclear pro-

ton and emerge as a high-speed proton, has been found in a study of neutron-proton scattering. Interactions of this type have long been proposed as contributing to nuclear forces.

Application of X-Ray Diffraction Phase Determinations to the Study of the Structures of Crystals Containing Large Molecules

David Harker

General Electric Company

(Invited paper)

Crystals are three-dimensionally periodic structures with repeating units composed of a small number of atomic groupings which may be molecules or ions. The electron distribution of a repeating unit gives rise to variations in the intensities of X-rays diffracted by the crystal in different directions. It is possible to correlate the directions of diffraction with sets of three integral numbers, h, k, ℓ; and the intensities diffracted in these directions can be interpreted as the squares of the corresponding coefficients of the Fourier Series representing the electron distribution in a repeat unit of the crystal. Thus, the Fourier Series for a crystal is

$$\rho(x, y, z) = \frac{1}{V} \sum_{h=\alpha}^{\alpha} \sum_{k=\alpha}^{\alpha} \sum_{\ell=\alpha}^{\alpha} F_{hk\ell}\, e^2\, \pi i(hx + ky + \ell z),$$

where $\rho(x, y, z)$ is the density of electrons at the point (x, y, z); V, the volume of one repeat unit; h, k, and ℓ, integers; and $F_{hk\ell}$, a number whose square has a magnitude proportional to the observed intensity of X-ray diffraction in the direction characterized by h, k, and ℓ.

The difficulty in finding a structure from an X-ray diffraction pattern is due entirely to the fact that the sign (or phase) of $F_{hk\ell}$ cannot be found from $|F_{hk\ell}|^2$, which is what is observed. Various methods of solving this problem have been attempted —none with complete success. Of these, the one due to J. S. Kasper and the speaker seems most likely to lead to the determination of such complex structures as those of proteins.

This method is based on the discovery that the signs (or phases) of some $F_{hk\ell}$'s are related to the squared magnitudes, $|F_{h'k'\ell'}|^2$, of other $F_{h'k'\ell'}$'s. These relationships are in the form of inequalities, such as

$$\frac{|F_{hk\ell}|^2}{(Z\hat{f}_{hk\ell})^2} = \frac{1}{2}\left(1 + \frac{F_{2h2k\ell}}{Z\hat{f}_{2h2k\ell}}\right),$$

where $(Z\hat{f}_{hk\ell})^2$ is the maximum possible diffracted intensity in the h, k, ℓ direction for any arrangement of the atoms in the given crystal. The use of this and analogous inequalities can yield the signs (or phases) of enough $F_{hk\ell}$'s to allow an approximate determination of the values of $\rho(x, y, z)$, i.e. of the crystal's structure. This crude picture can then be refined by other well-known methods.

Some Recent Studies on Fluorescence

W. Albert Noyes, Jr.

University of Rochester

The study of fluorescence provides one means of obtaining information on the transfer of energy between molecules on collision. The blue fluorescence of acetone has been studied

with sufficient care to show that there are discrete bands. Thus, either it is emitted by excited molecules of acetone or by free radicals in the excited state. There is not enough energy for the latter process. The temperature dependence of the fluorescence indicates that the excited molecules have a stability dependent on vibrational excitation. The transfer of energy between polyatomic molecules during collisions of the second kind has never been fully investigated. The relationship between energy transfers of monatomic, diatomic, and polyatomic molecules is briefly discussed.

Long-Distance Interaction Between Protein Molecules

Alexandre Rothen

Rockefeller Institute for Medical Research

(Invited paper)

When films of antigen (protein or polysaccharide) are transferred onto metal slides, these films are capable of adsorbing specifically layers of homologous antibody as much as 300 A. thick under certain conditions. Blankets made of barium stearate, octadecylamine, or different plastic materials can be deposited upon the antigenic layers. It is found that, when immune homologous antisera are deposited on top of such blankets, a specific immobilization of homologous antibody takes place in spite of the intervening thickness of the blanket. The possibility of holes in the blankets, thus allowing the antibody molecules to come in direct contact with the antigenic layers by diffusion seems contrary to the experimental evidence. The conclusion is reached that interaction between large molecules involved in immunological reactions may take place through a field of specific long-range forces extending over 200 A.

Experimental evidence indicates that certain enzymes can exert their action on films of antigen through intervening blankets of plastic material. The thickness of the blankets necessary to protect the antigenic layers depends greatly on the number of these layers and their mode of deposition—a fact which shows that the phenomenon involved is not a simple diffusion of the enzyme molecules.

The Size, Shape, and Charge Distribution of Protein Molecules

J. L. Oncley

Harvard Medical School

(Invited paper)

Protein molecules, unlike other macromolecules, usually contain large numbers of positively and negatively charged groups as well as polar and nonpolar groups arranged in specific positions in rigid structures. Many chemical and biological properties of proteins depend upon the size and shape of these molecules and the positions of the groups in the molecules. These quantities are fundamental in any theory describing the electrostatic interactions and the molecular-kinetic behavior of proteins.

Estimates of size, shape, and charge distribution have now been made for many proteins. These estimates have been obtained from studies of sedimentation and diffusion, osmotic

pressure, viscosity, double refraction of flow, and dielectric constant.

As a first approximation, protein molecules may be represented as ellipsoids of revolution, although these shapes are unquestionably too simple to be completely adequate. Using this assumption, scale models have been constructed of a number of proteins characterized in our laboratory. The β_1-lipoprotein is the most symmetrical of these molecules, but a number—serum albumin, egg albumin, and β_1-metal binding protein—have only slight asymmetry. Fibrinogen appears to be far more asymmetrical, a property closely related to its ability to form clots under certain conditions. Completely undegraded gelatin, more like fibrous proteins and synthetic polymers, has about the same length but half the width of fibrinogen.

In certain cases physical-chemical studies have led to more detailed models. Insulin, as it exists in neutral aqueous solution, has been demonstrated to be reversibly dissociated into three smaller units in acid solutions. Hemoglobin under quite different conditions dissociates into two smaller units.

Electromotive force measurements, combined with analytical studies of the amino acid composition, give reliable estimates of the number of positively and negatively charged groups. The distribution of these charges, as evaluated from dielectric constant measurements, is sufficiently asymmetrical to yield dipole moments much greater than those of other known molecules. The most asymmetrical charge distributions were observed for β-lactoglobulin, serum γ-pseudoglobulin, β_1-metal binding protein, and edestin. Egg albumin and serum albumin appear to have almost symmetrical charge distributions.

Although finer tools will be required to give detailed descriptions of molecules as complex as even the simplest protein, this approach to our understanding of their structure has yielded helpful models of proteins.

Synthesis of Polypeptides

R. B. Woodward
Harvard University
(Invited paper)

Complete hydrolysis of proteins by drastic chemical methods gives mixtures of α-amino acids. By gentler chemical methods, and in particular by enzymatic processes, cleavage products may be obtained which contain two, three, or more amino acids linked by simple amide bonds. These facts have led to the view (Fischer) that the fundamental structural feature of all proteins is that of a long polypeptide chain. The occurrence of variously constituted amino acid units, the opportunity for many different arrangements of units within the chain, and in particular secondary structural features, such as cross-linking between chains by primary bonds, hydrogen bonds, or ionic forces, and manifold opportunities for coiling of long chains, all serve to differentiate the various natural proteins and to confer on each individual certain characteristic properties. In general, these secondary structural characteristics appear to be more important in defining the properties of the globular proteins than of the fibrous proteins. The latter have properties more nearly like those to be expected of rather simple high polymers having the fundamental chain unit (—CO—CH(R)—NH—), though even in this class the molecules do not appear to consist of single chains, but rather of bundles of two or more chains which may associate end to end in the formation of fibrils. Denaturation, the transformation of globular proteins to fibrous modifications, probably involves the unfolding of such a bundle of polypeptide chains, which in the globular modification is tightly coiled in a very specific manner.

The properties of the proteins and the structures to which these properties may be attributed are clearly very complicated, but no evidence has been forthcoming which indicates that the complication is one of kind rather than of degree. To the organic chemist the structural forces in the proteins are the same as those operative in the simple molecules with which he is familiar, and the complications arise only from the large numbers of combinations and arrangements of simple atomic interactions. Classically, the task of the organic chemist, once the fundamental structural features of a molecule have been elucidated, is that of synthesis—the duplication to the extent that is possible, of the structure put before him. In the case of the proteins, the first step is clearly that of developing methods for the synthesis of long polypeptide chains. The classical many-step methods of organic synthesis are unsuited to the preparation of materials of high molecular weight, and it is clear that the solution of the problems requires the use of the methods of addition polymerization or an analogous process.

The monomeric species for such a scheme, and indeed the addition polymerization reaction, have long been known, though not recognized as such. Recently, by the polymerization, under carefully chosen conditions, of properly constituted monomers, the synthesis of molecules containing long polypeptide chains with any desired number of different units has been achieved. The preparative results as well as mechanistic considerations and the molecular and physical properties of the products are discussed. The extent to which the phenomena shown by the synthetic materials duplicate those of natural proteins and possibilities for the future, particularly in the testing of hypotheses as to correlations of properties of natural proteins with structural features, are considered.

The Nutritional Significance of Amino Acid Imbalance

C. A. Elvehjem
University of Wisconsin

An interesting relationship between vitamins and amino acids was established when a niacin deficiency was produced in the rat through the use of a diet high in corn and low in proteins. This deficiency was counteracted by the addition of niacin or tryptophane. Evidence is available that tryptophane may function as a precursor of niacin in the animal body.

Further studies with synthetic rations containing 9 per cent of casein have shown that protein hydrolysates, mixtures of amino acids, and specific amino acids produce a significant retardation in growth which may be reversed by the addition of either niacin or tryptophane. Threonine and phenylalanine showed the highest activity of any of the amino acids tested.

The significance of this amino acid imbalance in the prevention of pellagra, in the use of protein hydrolysates and amino acids in therapy and in laboratory studies in which free amino acids are used in place of the intact protein, is discussed.

The Site of Cell Growth

Paul Weiss
University of Chicago

When a nerve fiber is partially constricted, the part lying distal to the constriction (*i.e.* at the far side from the cell nucleus) assumes a reduced diameter, while an excess of cytoplasm piles up at the proximal (*i.e.* near-nuclear) side of the "bottleneck." This condition becomes permanent. Various experiments of this type have led to the conclusion that nerve cells are in a state of sustained growth, new protoplasm being continually produced at the site of the cell nucleus and then pressed distad into the fiber. Constriction causes the observed changes in fiber caliber by throttling the centrifugal convection of cytoplasm. When the constriction is later removed, the dammed up cytoplasm can be seen to advance distad. The rate of this advance is of the order of 1 mm./day.

In explanation of this phenomenon, the hypothesis is proposed that the basic protoplasmic systems of the cell, particularly native proteins, cannot be synthesized in the cytoplasm but must be supplied from a nuclear source. On this premise, the rate of presumable natural protein decay in nerve was calculated from known values of ammonia production, and from this the rate of replacement requisite for maintenance of steady state could be derived. This postulated replacement rate was found to be of the same order as the observed rate of proximodistal convection of protoplasm, thus lending support to the proposed concept.

The results indicate a very close relation between the genic apparatus of the cell, protein reproduction, and the sources of protoplasmic growth.

Some Theoretical and Experimental Relationships Between Infrared Absorption and Olfaction

Lloyd H. Beck and Walter R. Miles
Yale University

According to the proposed theory, olfaction results when the radiation of heat from an organism's receptors is accelerated. The source of heat is the organism itself. The organismic source defines the critical region of the infrared spectrum as that in the neighborhood of the maximum of a black body at approximately $290°–313°K$. The receptors, being of the dimensions of the wave lengths in the region of this maximum ($8–14\,\mu$), can, by virtue of their size and shape, radiate selectively. Any substance having an absorption band in this region and coming within the radiation field of these receptors will cause them transiently to lose energy. This transient loss of energy is presumably the initial event in the process of stimulation of the olfactory receptors. Differential radiation losses of the receptors account for olfactory quality as spatial stimulation.

In a group of roaches (*Periplaneta americana*) placed between glass chambers equipped with potassium bromide (KBr) windows, one of which was backed with glass, 15 per cent showed antennal activity when air was pulsed through the chambers, 24 per cent showed activity when oil of clove vapor was pulsed through the chambers, and 26 per cent showed activity when oil of clove was released diffusely in the room. These results could have occurred by chance 3 times in 100.

The present theory rationalizes the experimental literature on olfaction. Among other points, it distinguishes odorous from inodorous substances; explains adaptation as the return of the receptor system to a new thermal equilibrium in the presence of an odorous substance; accounts for the differences between micro- and macro-osmatic animals on the basis of the larger absorption chambers of the latter; accounts for the anomalies in the chemical theory; and provides a basis for the reinterpretation of some of the classic work in olfaction.

Electrical Responses of the Human Retina to Stimulation by Lights of Various Wave Lengths

Lorrin A. Riggs
Brown University
(Introduced by Walter S. Hunter)

A contact lens is used to maintain a constant electrical contact between the cornea of the eye and a nonpolarizable electrode. Continuous records are made of the difference of potential existing between this electrode and a reference electrode located elsewhere on the head. When light enters the eye, an electrical response occurs which is manifested as a momentary increase in the positivity of the corneal electrode. That the effects so observed originate in the retina or sensitive layer of the eye has been shown conclusively in various control experiments. The exact nature of the retinal events underlying the electrical response is not well understood at present. The evidence from our recent experiments does show, however, that the scotopic or night visual system is chiefly responsible for the magnitudes and wave forms of the recorded responses. Responses obtained during the process of dark adaptation reveal, for example, that the sensitivity of the eye continues to rise over a period of more than an hour, even when tested with red light. The rate at which visual sensitivity appears to rise in these experiments is consistent with the scotopic portion of the curve of dark adaptation as conventionally obtained by determination of visual thresholds. In other experiments, the eye has been adapted to a constant level of illumination, whereupon electrical responses are elicited by means of test flashes of added illumination. The result again is consistent, for 5 different levels of light adaptation, with the predicted effects of such adaptation upon the scotopic system of the retina. In other experiments, various wave lengths of stimulating flash have been used to reveal the visibility function, based upon magnitudes of electrical response. This function resembles fairly closely the scotopic visibility curves which have been determined by many investigators using a conventional matching procedure. It is concluded that the contact-lens method of recording visual sensitivity has the following characteristics: (1) It provides objective and measurable responses which are not influenced by error of subjective estimation. (2) It reflects only the activity of the retina, uncomplicated by effects occurring in the higher visual centers. (3) It reveals the activity of the scotopic visual system under conditions of light adaptation such that scotopic functions cannot be observed by the usual psychophysical methods because of the intrusion of the photopic system. (4) In spite of the value of the electrical response as an indicator of scotopic sensitivity, its exact nature and point of origin are not well understood.

Infrared Absorption in Field Studies of Olfaction in Bees

Walter R. Miles and Lloyd H. Beck
Yale University

The problem in these studies was to determine if infrared absorption bands influence the olfactory behavior of bees. Duplicate units made of cast iron provided the chambers for liquid honey, gas from the honey, and a moisture absorber. An open cooling chamber adjoined the solid end of each gas chamber, a window being sealed into the other end. For chamber "S" the window was a special infrared filter. For chamber "XS" the same filter was used with glass behind it. On small platforms in front of each window a measured number of drops of honey were placed and exposed to the open air in order to attract the bees to work near and in front of the two windows. After the platforms were removed, the subsequent behavior of the bees was studied. They now clustered on the infrared passing window in the ratio of from 3–10 to 1 on the "XS" window. Variations of this experiment have demonstrated, in terms of proportional statistics, reliable indications that the bees prefer the window which passes infrared from the honeyed perfume inclosed in the chamber behind it. These results appear to support the hypothesis that infrared absorption bears a relation to the adequate stimulus for olfaction.

The Predictiveness of Infant Behavior Traits

Arnold Gesell
Yale University

The Yale Clinic of Child Development has made numerous diagnostic and follow-up studies of the growing behavior patterns of normal, atypical, and abnormal infants. The infants were examined at periodic intervals with stenographic recording. A clinical crib, a test table, and test objects were designed to elicit characteristic responses in the four major fields of behavior: motor, adaptive, language, and personal-social. Cinema records of the behavior patterns have been subjected to frame-by-frame inspection and to quantitative analysis. Selected children were observed for a period of 10 years; one pair of identical twins has been intensively followed from infancy for a period of 20 years.

These studies indicate a high degree of predictability in the sequences of mental growth. The sequences follow a general ground plan with variations which are distinctive for each individual. Normal infants in the first three months of life tend to lie with head and arm directed to one side, the opposite arm being crooked at the shoulder. This "tonic-neck-reflex" pattern may be right or left or mixed. Deep-seated preference for the left is predictive of ultimate lefthandedness.

With the aid of finely graded norms of behavior growth, a clinically trained diagnostician can appraise the developmental potentials of the infant. By systematic methods of developmental diagnosis it is possible to diagnose in the first year of life nearly all cases of amentia, cerebral injury, sensory and motor defects, and serious personality deviations. One or two examinations in infancy usually suffice to determine whether a child is suitable for adoption and whether the developmental outlook is favorable, highly favorable, or unfavorable. Examinations in infancy and observation during the preschool years may reveal various forms of giftedness, temperamental qualities, individual modes of growth and learning, and liabilities and assets in emotional make-up.

All these possibilities in the realm of prediction have been demonstrated by clinical applications which operate with significant success when based on a precise knowledge of the developmental mechanisms involved. This knowledge is now only in its crude beginnings. The task of science is to refine the knowledge. Refinement of knowledge will lead to refinement of prediction. A greater concentration of scientific resources on the period of early infancy becomes of supreme importance for preventive medicine and other forms of social control.

Tepexpan Man: A Study of an Ancient Human Skeleton From the Valley of Mexico

Javier Romero
Museo Nacional of Mexico
T. D. Stewart
U. S. National Museum
(Introduced by Alexander Wetmore)

Restoration and study of the human skeleton of late Pleistocene age from near the present town of Tepexpan, Mexico, has now been completed by Sr. Romero under the guidance of Dr. Stewart. Restoration has involved reassembling the broken parts of the face and of the major long bones. The skull is reasonably complete, but the long bones, except for the right radius and ulna, are deficient. Only a few other parts are present or complete enough for study.

In shape, the skull is on the border of brachycrany (C.I. 80) and relatively high. Cranial capacity is high (1,540 cc.), and the endocast shows a well-developed brain. The skull type is close to that of the late Indians of our Southeast. Suture closure indicates advanced age (55–65 years). Sex characters are masculine.

Computation of stature from long-bone measurements yields a figure of approximately 170 cm., which is well above the present average of Mexican Indians. Arthritic changes, notably in the cervical vertebrae, are consistent with the attributed age.

A sculptural representation of the soft parts of the head, built upon a cast of the skull and taking into account average tissue thicknesses for whites, shows a typical Indian countenance. This head epitomizes the conclusions of the study, namely, that Tepexpan Man was a typical Indian, although bigger than those living today in Mexico.

The Viking Fund of New York made it possible for Sr. Romero to bring the specimen to Washington, where the Smithsonian Institution supplied laboratory facilities and study collections.

Bikini Revisited—Preliminary Results of the Scientific Resurvey During the Summer of 1947

Commander Roger Revelle, USNR
Geophysics Branch, Office of Naval Research

During July and August of 1947 the Navy Department, in cooperation with other government agencies, carried out a scientific resurvey of Bikini Atoll in order to study the effects of radioactivity on marine organisms living in a natural environment and to extend certain aspects of the geological,

biological, oceanographic, and military investigations conducted in this little known area during 1946. Approximately 60 civilian scientists and technicians participated in the resurvey, representing the U. S. Geological Survey, the Fish and Wildlife Service, the National Museum, the Navy Department, the Atomic Energy Commission, and various universities and research institutions. Four ships were assigned to the expedition including the *U.S.S. Chilton*, a transport of about 15,000 tons.

Although fishes and other marine animals from the entire lagoon area were often found to contain slight amounts of radioactivity, no large-scale changes were observed in population density of reef or pelagic animals or in the relative abundance of different species. Some coral patches in the target area showed evidence of destructive effects due to the atomic bomb explosions. Reproductive processes in living organisms appeared normal, and no morphological changes were found. Studies of permeability, salt accumulation, bioelectric potential, pigment content, photosynthesis, respiration, enzyme activity, and calcification were carried out on marine algae. Only one difference, a higher activity of the hydrogen peroxide decomposing enzyme, catalase, was noted between areas which had received heavy doses of radiation from radioactive substances and those which had not been affected by radiation. Marine bacteria and land organisms appeared unaffected by radiation. In the eastern end of Bikini lagoon the water is considerably more turbid than in the spring of 1946; the cause of this change is not well understood.

The subsurface structure of Bikini Island on the eastern end of the atoll was explored by core-drilling down to a depth of 2,556 feet, nearly two and a half times as deep as the Funa Futi boring, the only previous drilling on a coral atoll. Unconsolidated or very poorly consolidated calcareous sediments—beach rock, reef limestone, coral rubble, and calcareous sand—were found at all depths. Preliminary examination by geologists and paleontologists of the U. S. Geological Survey shows that late Tertiary corals and mollusks were encountered at 930 feet, and it is possible that the top of the Tertiary section may be considerably higher. Seismic velocity determinations in the deep hole suggest a continuous transition to more compacted calcareous materials near the bottom. On the basis of previous geophysical evidence, these may extend down to depths of one to more than two miles.

Studies of the deposition of calcium carbonate indicate a rate of upward growth of the reef of about 1 mm. per year.

Twenty-four dredge hauls were made on the outer slopes of the reef. These show that the outer slope consists near the surface of large blocks of limestone mixed with calcareous sand. The size of the blocks decreases with depth from several tons near the surface to several hundred pounds at depths of more than 200 fathoms. Below 200 fathoms these limestone blocks are rare. From 10 to 100 fathoms, living corals, algae, bryozoa, sponges, and other forms are present in abundance. The profusion and variety of life decreases rapidly with depth; below 100 fathoms the predominant forms are foraminifera, algae, a few deep-water corals, sponges, and brachiopods.

NEWS
and Notes

The winners of the two $1,000 AAAS-George Westinghouse Science Writing Awards for 1947 were selected in New York City on November 20. George A. Keaney, feature writer on the *New York World-Telegram* won the 1947 Newspaper Writing Award for his series of five stories on blood, and more especially on the Rh factor of blood, which appeared in the *New York World-Telegram*, March 18–22, 1947. This year's Magazine Writing Award was won by Steven M. Spencer, associate editor of the *Saturday Evening Post*, for his story, "New Hope for the Anemic" (an article on folic acid), which appeared in the December 14, 1946, issue. The judges further recommended that honorable mention for the Magazine Writing Award be given Lorus J. and Margery J. Milne, free-lance writers,

for their article, "The Life of the Water Film," published in the June 1947 issue of *Natural History*.

A newspaperman for only three years, Mr. Keaney had taught English and civics in the Lawrence, Massachusetts, high school for 13 years. He was born in Lawrence in 1906 and later received his A.B. and M.A. degrees in English from Boston College.

Steven Spencer was awarded a Nieman Fellowship in Journalism at Harvard University in 1939 while he was employed on the *Philadelphia Bulletin* as staff science writer. He later contributed articles to the *Saturday Evening Post* and joined its staff in 1946. Mr. Spencer was born in Omaha, Nebraska, and received an A.B. degree in English at the University of Pennsylvania. He is now living in Swarthmore, Pennsylvania.

The Milnes have contributed to several general circulation magazines during the last year as free-lance writers. They are now living in Burlington, Vermont, where Dr. Milne is associate

professor of zoology in the University's Department of Zoology. Mrs. Milne was formerly associate professor of biology at Beaver College, Jenkintown, Pennsylvania.

The $1,000 Newspaper Writing Award was made for the first time at the Boston meetings of the AAAS in Chicago, and the Magazine Writing Award was incorporated into the annual program for the 1947 contests. Both of the 1947 awards will be made at a presentation dinner on December 27 during the AAAS meetings in Chicago. Upon this occasion Dr. Shapley will act as toastmaster, and the guest speaker will be George Stoddard, president of the University of Illinois. Through funds provided by the Westinghouse Educational Foundation of the Westinghouse Electric Corporation and under the administration of the AAAS, the annual science writing awards are made in an effort to stimulate and maintain a high standard of science reporting for the lay public through the newspapers and the general circulation magazines.