The National Academy of Sciences: Abstracts of Papers Presented at the Autumn Meeting, November 9-11, 1953

Source: *Science*, New Series, Vol. 118, No. 3072 (Nov. 13, 1953), pp. 567-578
Published by: American Association for the Advancement of Science
Stable URL: https://www.jstor.org/stable/1680167
Accessed: 07-12-2018 20:00 UTC

NATIONAL ACADEMY OF SCIENCES

Abstracts of Papers Presented at the Autumn Meeting, November 9–11, 1953 Massachusetts Institute of Technology, Cambridge, Massachusetts

Properties of Gases at Extremely Elevated Temperatures

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Quantitative information concerning properties of gases at extremely elevated temperatures (of the order of 10^5 to 10^7 degrees Kelvin) in addition to its fundamental interest, is required in a variety of astrophysical problems and in certain problems dealing with combustion, detonation, and electric discharges in gases. The gas properties under present consideration include the transport properties, viscosity, conduction, and self-diffusion, and compressibility, as expressed by the second virial coefficient. Since direct measurements in the indicated temperature range cannot, in general, be made, and since long range extrapolation from low-temperature measurements may yield numerical values which are not even of the correct order of magnitude, a new approach is indicated.

In outline, the method consists of obtaining experimental information concerning the molecular interaction energies from the scattering of neutral particles of high energy (of the order of 200 to 2000 electron volts), and the use of this potential energy information in well-founded kinetic theory or statistical mechanical expressions to calculate the desired gas properties. The temperature range in which these properties are valid is determined by the range of interaction distance to which the derived potential energy information applies, and this, in turn, is determined by the geometry of the scattering system and the energy of the beam particles.

Results are presented for the gases, He, A, Ne, Kr, and Xe, which represent a favorable case because of the spherical symmetry of the intermolecular force fields and the almost completely elastic character of the molecular collisions. The presence of asymmetric force fields and the effect of inelastic collisions are discussed in connection with the use of the present method to obtain information for polyatomic gases.

The Dynamic Analysis of Low-Aspect-Ratio Airplane Wings

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Unique problems are described which arise in the theoretical study of the effects of flexibility on dynamic flight behavior of modern aircraft wings with triangular, narrow rectangular and related planforms. A typical phenomenon is flutter, an oscillatory instability under fluctuating air pressures, where the wing deforms as an elastic surface in a complicated mode of vibration. The aerodynamic and structural tools necessary for successful prediction of flutter are outlined, with examples to illustrate certain pitfalls that may be encountered. Comparisons are presented between results obtained theoretically and in the wind tunnel for specific triangular and rectangular wings.

A discussion is given of difficulties which will have to be overcome during future research in this field, among others the more precise determination of structural properties and extension of existing aerodynamic theory. Improved techniques are suggested for stating and systematizing the equations of motion and their solution, including an alternative to the classical method of modal superposition.

Metabolic Effects of a Pituitary Extract

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Purification of corticotropin by oxycellulose adsorption after hot glacial acetic acid extraction of pituitary glands yields a highly active preparation of enhanced clinical effectiveness. The product is virtually free from growth, thyrotropic, and gonadotropic activities and is rich in intermedin; the latter may be partially separated by any of several methods. A small quantity of crystalline spermine may be recovered from the extract. The preparation produces a number of metabolic effects, the factor or factors responsible for which have not yet been separated from corticotropin. In the fasting mouse, 3 μg causes a considerable mobilization of depot fat to the liver within three hours, the metabolic rate rises, and acetonuria occurs; in fed animals, the extract lowers the R.Q. These effects occur in adrenalectomized or hypophysectomized mice if they be maintained with cortisone. Larger doses protect the fed or fasted, intact or adrenalectomized mouse against the hypoglycemic and convulsive actions of insulin, but paradoxically the extract consistently lowers the blood sugar when given alone. The hypophysis is conceived as exerting an essential regulatory action in the normal utilization of fat during fasting and may thus be concerned in clinical states of over- and undernutrition.

Tensile Strength of Thin Metallic Films[1]

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University of Virginia

The tensile strengths of thin films of silver and of copper have been measured as a function of their thickness. The experimental method consists in electro-depositing the metallic films on the cylindrical surface of a small diameter rotor and measuring the rotor speed at which the films are thrown off. The rotors are magnetically sus-

[1] Supported by the Navy BuOrd and OOR.

pended in a vacuum and spun by a rotating magnetic field in a manner previously described (*1*). In this way the stresses are applied to the film uniformly and tearing or stress concentrations are avoided. By using rotors of different diameters, both the tensile strength and the adhesion may be obtained. However, in most of the experiments the adhesion was made vanishingly small by thermally cycling the rotor from 90° to −70° C. Also, the adhesion was separately determined by electro-depositing the films on the rotor in circumferentially disconnected patches. The tensile strength of the silver films was found to be practically independent of thickness down to thicknesses between 3 and 2×10^{-5} in. where an abrupt increase of at least twentyfold occurred. These results are similar to the well known increased tensile strength observed in fine fibers and very thin sheets of mica (*2, 3*).

References

1. BEAMS, J. W., YOUNG, J., III, and MOORE, J. *J. Appl. Phys.*, **17**, 886 (1946).
   BEAMS, J. W., WALKER, W. E., and MORTON, H. S., JR. *Phys. Rev.*, **87**, 524 (1952).
2. GRIFFITH, A. A. *Trans. Roy. Soc., London*, **221**, 163 (1921).
3. OROWAN, E. *Z. Physik*, **82**, 235 (1933).

The Industrial Separation of Isotopes

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The development of nuclear power plants has given importance to the separation of isotopes of a number of elements on an industrial scale. Individual isotopes of present or potential value include: D^2, Li^6, Li^7, B^{10}, N^{15} and U^{235}. There is also a substantial demand for C^{13} and O^{18} as tracers in research.

Uses of these isotopes and unclassified information regarding their production are reviewed. The principal processes for large scale separation of isotopes are described. It is concluded that distillation and chemical exchange are the most economical processes for separation of isotopes of the lighter elements. Gaseous diffusion and the gas centrifuge are useful for U^{235}.

The Shock Tube in Aerodynamic and Structural Research

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The shock tube has recently been developed as a tool for laboratory studies of gas dynamic phenomena. The well developed theories and practical applications of shock tubes are discussed. A shock tube design is described which is particularly suited for studying the effects of moving shock waves on structures. Applications of the tube to gas dynamic studies in the subsonic, transonic, and low supersonic ranges are discussed. In addition, applications to structural response problems arising from moving shock waves are described. Illustrations of results and data are given for some specific cases.

Some Reactions Involved in Biosynthesis of the Purines

John M. Buchanan
Massachusetts Institute of Technology

Studies have been carried out on the enzyme system responsible for the conversion of 4-amino-5-imidazolecarboxamide to inosinic acid in pigeon liver extracts. Recent experiments in this laboratory have shown that 4-amino-5-imidazolecarboxamide riboside may be formed from 4-amino-5-imidazolecarboxamide and ribose-1-phosphate in the presence of purified nucleoside phosphorylase. Greenberg has demonstrated that the carboxamide riboside may be phosphorylated by ATP to form the corresponding ribotide in the presence of dialyzed pigeon liver extract.

The third step, the incorporation of formate into the 2 position of the purine ring, has been studied in this laboratory by incubating pigeon liver extract with inosinic acid and radioactive formate. A preferential incorporation of radioactive formate into the 2 position of inosinic acid has been noted and the further observation made that the citrovorum factor stimulates this reaction. These data have been interpreted to mean that the purine ring of inosinic acid cleaves yielding 4-amino-5-imidazolecarboxamide ribotide which recondenses with radioactive formate to form inosinic acid-2-C^{14}. The citrovorum factor (formyl CoF) is believed to be the transformylating coenzyme.

The extract has been fractionated into two components by ethanol. The optimal incorporation of formate occurs only in the presence of both enzyme fractions. Components of this optimal system other than the enzymes are: inosinic acid, radioactive formate, boiled juice of pigeon liver and citrovorum factor. The stimulatory effect of the citrovorum factor on the reaction occurs only in the presence of both enzyme fractions.

Some Aspects of the Phase Problem in Crystal-Structure Analysis

Martin J. Buerger
Massachusetts Institute of Technology

The problem arising when attempting to find the locations of atoms in crystals can be appreciated by considering the formation of an image in the two-wavelength microscope. In this microscope the formation of the image takes place in two steps. The first step comprises the phenomenon occurring in the flow of light from the object to its diffraction image, the second step from the diffraction image to the final image. If light of two different wavelengths, λ_1 and λ_2, is used in these two steps, it is necessary, at present, to photograph the diffraction image and then build the final image by diffraction from the photographed diffraction image. Because of the break in the process, the phases of the light rays are lost. This phase loss also characterizes ordinary crystal-structure analysis. For many years it was believed that the phases could not be recovered. It is now known that, when studying discrete atoms, the phases can be found. Furthermore, the relation is now known between the true image and the image produced by assigning the same phases to all rays in the second stage. In x-ray analysis, this relation is used to solve the Patterson synthesis. An actual example of the use of this method of avoiding the phase problem is cited.

On Slow Viscous Flow

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The flow of a viscous fluid past an obstacle at low Reynolds number has been the subject of numerous analytical investigations. A rigorous analysis of the motion of the fluid requires the solution of a nonlinear problem, but

various attempts have been made to formulate an equivalent[1] linear problem. The work presented in this paper is a discussion of such a linear model which is closely related to the procedure introduced by Oseen. The results of the analyses of several specific boundary value problems using this model are presented and compared to those of the classical model of Oseen and Stokes. The results reported here are seen to be in better agreement with the physical facts than those given by the Stokes and Oseen theories.

Effects of Pyridoxal and of Indoleacetic Acid on the Transport of Amino Acids and of Potassium into Cells

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Amino acids do not enter living cells by simple diffusion; instead they are actively transported into the cell interior against concentration gradients. This concentrating activity helps to determine how much of the various amino acids is captured by each tissue of an animal. We have found this process susceptible to study in free-cell neoplasms, specifically in the Ehrlich mouseascites tumor. Amino acids of all sorts are transported very actively into these cells, so that their concentrations may quickly come to be 10 or 100 times as great inside as outside.

In looking for clues as to the nature of this transport apparatus we have observed two substances, pyridoxal and indoleacetic acid, which considerably increase the extent to which glycine and other amino acids are concentrated by the cells. These two must work in different ways because supplying both at once in optimal amounts gives at least the sum of the effects of each alone. Their effects are related, however, in that indoleacetate combats an inhibitory action of desoxypyridoxine although it strengthens inhibitory effects seen with high levels (above 0.01 *M*) of pyridoxal. The effects of pyridoxal are seen somewhat more strongly in tumor cells from B_6-deficient mice. High glycine loads increase somewhat the level of pyridoxal which is optimally stimulating. What is particularly interesting is that pyridoxal has effects upon the maintenance of the cellular potassium concentration which parallel those upon glycine; at levels above 10 millimolar the tumor cells, and also erythrocytes, lose potassium more rapidly than they gain sodium; consequently the cells shrink. The erythrocytes thereby become more resistant to osmotic hemolysis. Shrinkage is also produced by indoleacetate.

Studies of the Site of Antibody Formation

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Unequivocal evidence has accumulated in the last two decades that specific antibodies directed against foreign substances (antigens) gaining entrance to the animal body are synthesized primarily in the lymph nodes and spleen, at least in rabbits, guinea pigs, and mice. Closer study of the complex cellular changes in these organs following such a foreign stimulus has made it likely that this synthetic function is carried out primarily by one kind of cell, the plasma cell. By use of fluorescein-labeled antibodies, which form specific precipitates visible under the fluorescence microscope, both the foreign substance and antibodies directed against it can be localized to cells, and to parts of cells. With this method of observing the accumulation of antibody, we have shown that members of the plasma cell series in fact contain antibody. It has also been determined that the marked and long-known difference between the small response to a first stimulus and the great response to a subsequent stimulus is paralleled by the number of antibody-containing cells observed. The secondary response is characterized by cell multiplication, cell differentiation, and antibody synthesis.

These changes will be illustrated.

[1] "Equivalent" in the sense of yielding a solution closely approximating the vigorous solution.

Nucleon-Shell Effects in the Fission Yield Pattern

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The process of nuclear fission leads to a broad distribution of the fission products, centering for U^{235} neutron fission on mass numbers 95 and 139. Previous work has established the main features of the yield-mass curve and of the most probable charge and its distribution (i.e., independent yield along a decay chain) for a given mass ratio. The majority of these results come from quantitative radiochemical studies of the radioactive products. Mass spectrometric studies started in the school of H. G. Thode show the occurrence of fine-structure in yields, which is quite pronounced in the mass region 132–138. It is expected that effects should be observed from the occurrence of closed-shell effects for 50 and 82 neutrons and for 50 protons. This study was made to evaluate such effects in the fission yield pattern.

Data are presented coming from a search for new fission activities of antimony and a re-study of those of tellurium and iodine, with determination of cumulative and independent fission yields for as many species as possible. New species identified include: $\sim$ 12m Sb^{130}, 23.1m Sb^{131}, 1.9m Sb^{132}, 4.1m Sb^{133}, and 0.8m $Sb^{134, 135}$, together with $\sim$ 2m Te^{133}, the ground state of 63m Te^{133m}.

The pattern of independent fission yields leads us to modify the equal charge-displacement hypothesis of L. E. Glendenin to take into account discontinuities in probable charge associated with shell-regulated discontinuities in the pattern of stability. The cumulative fission yields for chains 130–140 show oscillations correlated with enhanced neutron boil-off for primary fission fragments with an odd neutron number above 82. Evidence is also deduced for the postulate of D. R. Wiles that closed-shell species have higher fission yields.

Recent Technical Applications of Karman's Vortex Wake

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The wake behind an obstacle in a fluid stream exhibits a regular pattern of vortices which are washed off the body periodically, alternately from the two sides, which gives rise to an alternating force on the obstacle in a direction perpendicular to that of the fluid stream. These vortices were described in the fifteenth century by Leonardo da Vinci; their frequency law is due to Strouhal (1878), and the geometry of their pattern was calculated by Karman (1911) for a circular cylinder. The intensity of the alternating force is only approximately known at present, especially for high Reynolds' numbers. When the frequency of vortex shedding (determined by the stream

velocity and the size of the object) is near a natural frequency of vibration of the object, large motions result which have led to structural failures. Important technical applications are electric transmission lines, submarine periscopes and large industrial smokestacks. The failure of the Tacoma, Washington, suspension bridge in 1940 was explained on this basis. Steel smokestacks for power stations are now reaching proportions which are unsafe in the wind, necessitating special damping devices.

High-Strength Plastics

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High-strength plastics, composite structures of resins and high-strength filaments, are rapidly finding use in diverse applications like aircraft, body armor, fishing rods, watercraft, automobile bodies, and radar housings; they are entering the fringes of large-volume fields like building components.

Resins include phenolic, melamine, silicone, and the low-pressure polyesters. Fibers are usually fine high-strength glass filaments, but others, particularly nylon, are employed to meet requirements like high-energy absorption and abrasion resistance. Other synthetics and a variety of vegetable fibers and papers also find use.

Reinforced plastics are reasonably isotropic when fibers are randomly distributed as in a mat or molding, but reinforcement is often deliberately oriented to develop maximum mechanical properties in desired directions. Such materials are anisotropic, and the mechanics of Hookean isotropic materials do not apply. The more complex theory of anisotropic materials must be employed, but the additional complexity is offset by flexibility and freedom in tailoring strength properties to fit the stress conditions, and in modeling structural forms to fit the loads and space requirements.

Important problems remain. These include the meagerness of existing information respecting elastic constants and mechanical behavior, development of absolute intimate bond between resin and fiber, high costs, and improved fabricating techniques.

The Direct Observation of Hapten-Antibody Equilibria

Paul Doty and Samuel Epstein
Harvard University

On the assumption that antibodies are divalent, their reaction with divalent haptens should be formally equivalent to the polycondensation reactions of bifunctional acids and bases. This proposition can be examined directly by determining the extent of "polymerization" of antibodies as a function of the relative concentration of hapten. Since the contribution of the hapten to the weight average particle weight of a dilute solution of hapten-antibody aggregates is negligible the extent of polymerization can be determined directly from the measurement of this type of average molecular weight. Using light scattering methods to obtain this result the reaction of anti-arsanilic antibodies with two divalent arsanilic acid haptens has been studied. At the low concentrations (0.05% antibody) employed the average particle weight does not exceed twice the antibody molecular weight. As expected on the basis of the foregoing proposition the average particle weight is found to pass through a maximum as the hapten concentration is varied. The free energy of formation of the hapten-antibody bond in these systems is about 5.5 kcal in agreement with the estimates of Eisen and Karush based on equilibrium dialysis. In addition the light scattering techniques permit the study of the reversibility of the reaction, the inhibition by excess hapten (divalent and monovalent), the temperature dependence of the equilibria leading to the heat and entropy of the reaction, and to some extent the kinetics involved. All these explorations require purified antibody which is not susceptible to nonspecific aggregation. (The help of Prof. William C. Boyd was invaluable in obtaining such preparations.)

Matter and Radiation in Expanding Universe

G. Gamow
George Washington University

It was customary until recently to speak about "ponderable" matter, and "imponderable" radiation. Even after Einstein's proof that any form of energy, and in particular radiant energy, possesses a certain mass, the mass of radiation under any ordinary physical circumstances was considered to be negligible as compared with the mass of (atomic) matter. However, from the cosmological point of view, the situation appears rather different, and, in fact, we may say that during the early epochs of the evolution of our universe, the total weight of the radiations must have exceeded quite considerably the total weight of ordinary matter. While at the present stage of expansion the mean density of radiation in space may be only a fraction of a per cent of the mean density of matter, a more rapid variation of radiation density with linear dimensions (fourth power of linear dimensions, as compared with third power in case of matter) insures that sometime in the past radiation density was greater than matter density. Using the formula of the general theory of relativity, one can show that the demarcation point between radiation-governed and matter-governed universe corresponds to the age of $2.6 \cdot 10^8$ years (counted from the beginning $5 \cdot 10^9$ yr ago), and that during this era the temperature and density in the universe were 170° K, and $7.5 \cdot 10^{-27}$ g/cm³. During the radiation period of expanding universe its temperature, and matter density were given by expressions : temperature =

$$[1.5 \cdot 10^{10}\ ^\circ\mathrm{K}]/[\text{age in seconds}]^{1/2}$$

and

$$[4 \cdot 10^{-3}\ \mathrm{g/cm^3}]/[\text{age in seconds}]^{3/2}.$$

Recent Observations on the Vasoconstrictor and Vasodilator Functions of the Sympathetic Nervous System[1]

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In dogs, anesthetized with sodium pentobarbital, blood flow was measured separately in cutaneous and skeletal muscle vascular beds using an electromagnetic flowmeter.

The muscle vascular bed responded by marked dilation to: a brief period of ischemia, and to intra-arterial injections of acetylcholine, and of buffered solutions adjusted to either high or low pH. In contrast, the cutaneous bed dilated only in response to intra-arterial injections of solutions of low pH; it was poorly reactive to ischemia and to injections of acetylcholine and constricted with solutions of high pH.

Both cutaneous and muscular beds constricted in re-

[1] Supported by National Heart Institute, USPHS.

sponse to intra-arterial injections of both epinephrine and nor-epinephrine. Secondary dilation occurred in the muscle bed frequently after epinephrine and occasionally after nor-epinephrine. Electrical stimulation of the lumbar sympathetic chain caused constriction in cutaneous and muscular beds. Intra-arterial administration of adrenergic blocking drugs (Ilidar, Hoffmann-La Roche; Dibenzyline, Smith, Kline and French) blocked the constrictor response in skin to sympathetic nerve stimulation and to intra-arterial injections of either epinephrine or nor-epinephrine. In muscle beds the adrenergic blocking drugs abolished the constrictor response to nor-epinephrine, and to nerve stimulation and converted the response to epinephrine to marked dilation. Only Dibenzyline converted the constrictor response to nor-epinephrine to a mild dilator response. Consistently the blocking drugs unmasked a dilator response to sympathetic chain stimulation. This dilator response to sympathetic nerve stimulation, was always blocked by intra-arterial injections of atropine, whereas the dilator responses to epinephrine and to nor-epinephrine were unaffected. Recent evidence suggests that the sympathetic constrictor fibers are under the control of the medulla and carotid sinus reflexes, whereas the dilator fibers are controlled by the hypothalamus and cerebral cortex.

The blood vessels in skin are under the tonic constrictor control of the sympathetic nervous system only; they respond poorly or not at all to local metabolic influences. The blood vessels of muscle are also under the tonic constrictor control of the sympathetic system, but unlike skin, they may be dilated by sympathetic cholinergic fibers, and by a variety of local metabolic influences. The sympathetic constrictor impulses appear to be mediated by a nor-epinephrine-like substance.

A Late Pachytene Chromosome Map of the Male Mouse

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Roscoe B. Jackson Memorial Laboratory

Through the use of permanent squash preparations, made from the seminiferous tubules of young male mice and stained with aceto-carmine, acetic orcein and Sudan Black B, a provisional chromomeric map of the synapsed meiotic chromosomes has been constructed. The twenty pairs of chromosomes appear as well-defined bodies whose serial alignment of chromomere rows has made possible the drawing, study, and identification of the several elements of the chromosome complement. The plasmosome organizer is a part of the XY chromosome pair, the large plasmosomic nucleolus making possible the ready identification of the sex chromosomes. Chromosomes V and VIII have been identified through the use of Snell's translocation (5-8)A; all other autosomes have been assigned identifying letters pending the discovery of linkage group identity through the use of irradiation experiments. The chromomeric map differs in detail and in interpretation from Slizynski's earlier "banded" map of the mouse. The present map shows a total of 471 chromomeres, while the "band" map shows 817 transverse lines; however, the two systems can be somewhat reconciled if the vesiculate chromomeres are counted as two bands each and the punctate chromomeres as one band each, making a total of 757 apparent bands for the chromomeric map. Many of the structures which are delineated in the new map are at or near the limits of resolution of the compound microscope; the use of oblique illumination has made possible the detection and study of these small bodies and is quite necessary for success in the use of the map as a guide for further cytogenetic investigations.

Acoustic Orientation in Tropical Bats

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Harvard University

Laboratory and field studies of bats in Panamá, including species that feed on insects, fruit, fish, nectar of flowers, and blood of living animals, showed that they all emit pulses of high frequency sound and appear to use types of acoustic orientation similar to that previously described in the insectivorous bats of the family Vespertilionidae. Frequencies ranged from 15 to 60 kc and tended to be correlated inversely with the size of the bat. The common fruit-eating bat *Corollia* (family Phyllostomidae) is characterized by a spear-shaped nose leaf somewhat similar to the "horseshoe" of the European horseshoe bat *Rhinolophus*; but *Corollia* produces sounds resembling more closely those of the Vespertilionidae (which have no nose leaf) than the long duration, constant frequency pulses of *Rhinolophus* recently described by Möhres. The pulses may have some frequency modulation and are emitted through the mouth, as in the Vespertilionidae, rather than through the nostrils as in *Rhinolophus*. The fish eating bat *Noctilio* emits complex high frequency sounds while fishing, and some of this sound can be detected by an underwater hydrophone. The possible significance of these sounds will be discussed with reference to the diversified feeding habits of these bats.

Electron Emission and Breakdown

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Massachusetts Institute of Technology

For d.-c. voltages and gas pressures below a few atmospheres, Townsend's breakdown criterion applies, which makes the regeneration of the starting electrons the decisive issue. At high gas pressures and in crystals, we find electron emission commencing at fields as low as 10^5 v/cm. Since an ample electron supply is thus assured, new types of instability conditions become valid. In the presence of electron emission the onset of impact ionization, and conversely, in the presence of impact ionization the onset of electron emission, may lead to breakdown due to the contraction of the field by space charges. Stabilization, before the spark stage is reached, may be possible in certain cases if an effective electron trapping mechanism interferes. Various aspects of the stability of dielectrics in the presence of electron emission are discussed for gases, liquids and solids.

Molecular Vaporization of the Group IVB Elements

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Radio Corporation of America

Although it has been common knowledge that some elements in Groups VB and VIB vaporize in molecular form, similar information concerning the Group IVB elements has, to date, not been available. The present paper deals with the elements carbon, silicon, germanium, tin, and lead which were studied in a Dempster-type, 180° mass spectrometer. A small sample of the element under study was thermally vaporized (carbon by direct electrical heat-

ing, the others heated in suitable crucibles); the neutral particles coming off were bombarded with low-energy electrons; and the resulting positive ions were mass-analyzed.

The mass spectra obtained show that each of the Group IVB elements produce molecular as well as atomic species in the vapor phase. Exact quantitative evaluations are difficult as long as fragmentation patterns and relative ionization cross-sections are not known. The sublimation of graphite is of special interest because the C_3^+ ion was found to predominate, and molecules containing up to eight carbon atoms were detected. Even though heats of activation could be measured for the three most abundant species C_3, C_2, and C_1, no definite conclusion was reached concerning the atomic heat of sublimation of graphite.

The other four elements yield, upon vaporization, mainly monatomic species and lesser amounts of polyatomic molecules. Thus, in the vapor phase of germanium were found clusters containing up to seven atoms and comprising about 20% of all the particles. Similarly, polyatomic tin clusters were observed, while diatomic molecules were found for silicon and lead.

Reproduction of an Animal Virus

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Rockefeller Institute for Medical Research

The development in this laboratory of a photometric technique which permits precise enumeration of certain animal virus particles made possible quantitative investigations on the reproduction of these infectious agents. Influenza viruses are reproduced in discrete cycles of about 6 to 8 hours' duration. Successive cycles result from the sequential infection of separate host cells. The yield is approximately 100 virus particles per cell. Only complete, fully infective particles emerge from infected cells. No evidence for the emergence of immature, noninfective particles was obtained. The ratio of total to infective particles on emergence is constant and approaches a value of 1.0.

The rate of emergence of newly formed particles is constant and independent of the number of infective particles inoculated. The generation time, i.e., time to double the number of particles, is about 60 minutes. Infective particles become noninfective rapidly in a manner indicative of spontaneous decay. Under conditions existing in the infected host, the half-life of infective particles is about 150 minutes. Noninfective particles block susceptible cells and prevent the reproduction of infective particles. The proportion of cells blocked is a function of the ratio of noninfective particles to susceptible cells. When this ratio has a value of about 8, reproduction is prevented. With values for the ratio smaller than 8, the rate of emergence of newly formed particles is decreased. When the generation time is increased in this manner until it is equal to or longer than the half-life, no infective particles appear although reproduction is still occurring.

Electronic Energy in Solids

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The treatment of the motion of an electron in the periodic potential field as found in a crystal is discussed. Various recent approaches to the solution of this problem by use of the orthogonalized plane wave method and of the cellular method have shown results comparing favorably with x-ray emission data; it is shown how, from a limited number of accurate results calculated by such methods, detailed knowledge of the energy density of electronic states may be derived. Such approaches indicate the real possibility of obtaining, by existing methods, quantitatively accurate energy band schemes in solids.

The use of these calculations in considering certain physical properties of solids is discussed. An outline is given of the theory of the elastic constants of solids, which energy band theory has proved capable of explaining the electronic properties of the transition metals are also amenable to treatment, and indicate the need for accurate rather than approximate knowledge of the energy density of electronic states. Another application is to the calculation of the cohesive energy of various metals; also, recent calculations of the compressibilities of metals have been found to be in good agreement with experimental data.

The Nature of the Electrical Conductivity in the Earth

Harry Hughes
Harvard University

The variation of the electrical conductivity through the Earth is inferred from the induced effects on currents in the ionosphere and on the secular geomagnetic variations. An analysis of the distribution found shows it to be due to the Earth's mantle being a semiconductor and increasing in temperature with depth. Experiments have been made on suitable minerals at high temperatures and they are found to be semiconductors of the magnitude estimated with both electrons and metallic ions as the conducting particles. Which conducts in the Earth is still uncertain due to the unknown effects of pressure, and on the correct choice of mechanism depend estimates of the temperature and composition of the Earth's interior and theories of the origin of the geomagnetic field.

An Analysis of Coat-Color Inheritance in the Dog

C. C. Little
Roscoe B. Jackson Memorial Laboratory

An analysis of coat-color inheritance in dogs is based on over 2,000 animals raised at Bar Harbor and on data on about 20,000 animals derived from several thousand cooperative breeders elsewhere.

The basic loci involved are as follows:

1. A^s=self color, a^w="wild" color, a^y=tan, a^t=tan points;
2. B=black, b=brown;
3. C=full pigment, c^{ch}=pale "chinchilla";
4. D=intense pigment, d=Maltese dilution;
5. E=extended pigment, e^{br}=brindle, e=restriction (red or yellow);
6. G=dominant gray dilution, g=its absence;
7. M=dominant merle or dapple, m=its absence;
8. P=dark eye pigmentation, p=pink-eyed dilution;
9. S=solid pigmentation, s^z="Irish" spotting, s^p=piebald, s^w=extreme white piebald;
10. T=dominant "ticking," t=its absence.

These are all clear Mendelian genes. Their expression and interaction are discussed.

Soundfield Due to a Rotating Airfoil

Osman K. Mawardi
Massachusetts Institute of Technology

An exact relation is derived for the acoustic field due to a rotating airfoil. The near zone field predicted by this relation differs appreciably from that determined by conventional studies which neglect nonlinear phenomena. The far field, on the other hand, is in substantial agreement with the results of previous approximate formulations and is found to be adequately described by lines of rotating dipoles. The study is restricted to subsonic speeds.

Population Structure, Dispersal, and Species Formation

Ernst Mayr
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The roles of mutation and selection have been duly stressed in discussions of evolutionary change and of species formation. Much less is known so far about the role of one of several other factors affecting speciation, namely the population structure of species. This in turn depends on dispersal faculty and survival at different stages of the life cycle, on the mating system, on the length of generations, on changes in population density from year to year, and on various other ecological factors.

The most important of these factors seems to be the dispersal faculty, which might be defined as the ability of individuals of a species to overcome extrinsic barriers. In species with easy dispersal there is much intermingling of individuals from different populations. This results in considerable genetic and morphological uniformity over extensive geographical areas and in a low rate of species formation.

In species with low dispersal faculty populations become isolated from each other more easily and more effectively, and many of the isolated populations may, in the course of time, reach species level. The rate of species formation tends to be high in such forms. A special case is presented by types which normally have a low dispersal faculty, but are subject to occasional long distance dispersal, like certain types of land snails. Exact data on the rate of species formation of such forms are not yet available.

If species formation is defined as the origin of reproductively isolated populations, it is probable that in animals the rate of species formation is as much or more so a function of the ecological characteristics of populations (including dispersal) than of such purely genetic factors as mutation pressure.

The Distribution of Charge in Molecules and Crystals

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The form of the "electron charge cloud" in a molecule or crystal is of importance for two main reasons. In the first place, the charge density function helps us to understand the origin of the binding energy of a system and secondly, many of the properties of a system depend directly on the general disposition of charge within it. Starting from a given set of basic atomic orbitals, the charge density P may be calculated on any orbital theory: we may start with simple molecular orbital theory, adding configurations to improve the approximation, or from valence-bond theory (though more conveniently in a revised form) including finally all possible polar structure; and the predicted expression of P must ultimately agree. By appeal to the form of P it is possible to give very general and unified definitions of "bond order" and of "atom" and "bond" charges.

Two samples are given of the value of atom and bond charges. They determine the general form of the field outside a molecule and hence long range interaction and the early stages of chemical reactions. And in a crystal, where the coherent x-ray scattering is calculable directly from P, they allow us to define such quantities as an "effective atomic scattering factor" for a bonded atom.

Hardness and Atomic Structure

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The hardness of ductile crystalline materials, determined by their yield stress, may be due to one of two causes. Either it arises from the presence of obstacles hindering the movement of dislocations: other dislocations, inclusions, and foreign atoms, may act as obstacles. Or it represents the shear stress required to move a dislocation in an otherwise faultless crystal. It was usually assumed in the theory of plastic deformation that dislocations could move under very small stresses in a good crystal, and that any hardness a crystalline material may possess was due to the interaction between dislocations, or the action of various obstacles.

It can be demonstrated in the case of diamond that its high hardness cannot be due either to the complete absence of dislocations, or to their presence in extremely large numbers. The hardness therefore must arise from a very high value of the shear stress required for moving a dislocation in the lattice. The strong directional bonds of diamond, if acting across the slip plane in the dislocation, would explain why the movement of the dislocation requires high stresses. Very high values of the lattice energy (intrinsic pressure) would give the same effect.

In the case of metals, strong directional forces and high lattice energies are to be expected if many unpaired electrons are present in the outermost d-shell. Inspection of the periodic table shows that in fact all common hard metals, with the obvious exception of beryllium, satisfy this condition; those with intermediate numbers (3 to 7) of outer-shell d-electrons are: V, Cr, Mn, Fe, Co; Nb, Mo, Ma, Ru; Ta, W, Re, Os, Ir; Pa, U. This remarkable relationship between hardness and atomic structure has already been noticed by Pauling (*1*); its direct cause is apparently the high stress needed for moving dislocations.

In a certain temperature range, thermal energy becomes sufficient to overcome the interatomic forces opposing the movement of the dislocation. In this "dislocation softening range," analogous to the softening range of glasses, the yield stress must show a considerable temperature- and velocity-dependence. Below the softening range, the material is hard; at temperatures high above it, the initial hardness of the unstrained crystal is very low, often insignificant compared with the hardness acquired by plastic deformation, and both are relatively little dependent on temperature and rate of deformation.

Reference

1. PAULING, L. *The Nature of the Chemical Bond,* 2nd ed., p. 415. Ithaca, N. Y.: Cornell Univ. Press (1948).

The Brittle Fracture of Ductile Steels

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The classical Mesnager-Ludwik theory attributes brittle fracture in normally ductile steel to triaxiality of tension due to plastic constraint by a notch or crack; in a triaxial state of tension, the highest tensile stress can be higher than the uniaxial yield stress, and it may reach the value of the brittle fracture stress even if the yield stress is lower than this.

Experiments carried out by Dr. D. K. Felbeck and the writer have shown that a brittle crack produced in a low carbon steel plate at liquid nitrogen temperature does not propagate as a brittle crack under static tension at room temperature: instead, intense localized plastic deformation occurs at the tip of the initial brittle crack, followed by the formation of a very short fibrous crack which then suddenly changes over to a cleavage crack running across the plate at high speed with little if any plastic deformation. The most obvious interpretation of this phenomenon is that, in cases of typical brittle fracture, the tensile stress can reach the level of the brittle strengh because the yield stress of iron is raised very considerably by high velocity of deformation. If a crack runs rapidly, therefore, the yield stress can rise above the brittle fracture stress with little or no triaxiality of tension. This must be the cause of any highly brittle fracture in a ductile steel, because a significant triaxiality due to plastic constraint would have to be preceded by considerable plastic deformation.

The Rapid Measurement and Recording of Osmotic Pressure

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Osmotic pressure is generally considered in terms of equilibria established across ideal and semi-permeable membranes. Hours, days or even months are required to attain equilibrium conditions across artificial membranes in conventional osmometers. In this communication we shall describe an instrument which measures and records osmotic pressure in a matter of seconds. The instrument has been developed to study transient osmotic forces during the diffusion of solutes through nonideal membranes which restrict, but do not prevent entirely, the passage of solute molecules. Osmotic transients of this type occur continually in living systems and are specially important to the exchange of water and dissolved materials through capillary walls. They are important also for determining the mean molecular weight of polydisperse polymers such as Dextran.

Two small osmometers of the Hepp type are arranged in parallel and the solutions on the underside of each membrane are connected to each side of a differential conductance manometer. This manometer combines great sensitivity and stability with a low volume displacement (0.0023 mm^3 per mm Hg). A high pressure is applied to the solutions on the top of each membrane, thus firmly pressing each membrane upon its supporting surface and causing filtration into the two halves of the conductance manometer. If the solutions and membranes in each osmometer are identical then no differential pressure arises during the filtration process. However, if a solute is added to one osmometer and this solute is restricted relative to solvent in its passage through the membrane then a differential (osmotic) pressure arises which is sensed by the conductance manometer and recorded on an oscillograph. For large solute molecules such as plasma proteins, which do not pass through the membranes, the half-time for development of pressure is about 5 seconds and equilibrium is 95% complete within a minute.

Auto-Mutagenesis in the Mushroom, *Schizophyllum commune*

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In *Schizophyllum commune,* a typical member of the higher fungi and characterized by tetrapolar sexuality, obligatory crossmating is imposed and controlled by incompatibility factors at two loci, *A* and *B*. Each fruit accordingly produces progeny of four distinct mating types. Fertile matings occur between strains of these diverse mating types only in those combinations which yield the double heterozygote. In other combinations having *A* or *B* factors in common, heterokaryons—mycelia containing genetically dissimilar nuclei—of a unique type are formed. The common-*A* heterokaryon, which is stable and capable of indefinite vegetative growth, induces mutations in its component nuclei in frequencies up to 10^3 times the spontaneous rate for the same mutations in homokaryotic strains. These mutants belong to a limited number of distinct morphological types (about 10), each type differing from wild by a single, characteristic, altered locus. The age of the heterokaryon and the genetic history of its component strains determine mutation frequency and, to a lesser extent, the types of mutations induced. Available evidence indicates that heterokaryotic mutagenesis is an auto-induced process operating through the normal production of a mutagenic agent(s) which preferentially affects a limited number of loci in a regular and predictable manner.

Molecular Motion in Silicones

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While the chemical properties of the silicone polymers may be explained quite satisfactorily on the basis of their chemical composition, the distinctive physical properties of these polymers require some explanation in terms of molecular structure. Two theories have been advanced: one assumes rather tightly coiled linear molecules in the silicone polymer and postulates some uncoiling with increase in temperature, while the other theory postulates an extreme degree of motion of the dimethylsilyl groups about the silicon-oxygen bond. The first theory explains the small temperature coefficient of viscosity by the compensating uncoiling mechanism; the other theory explains the same property (and many others) by increased intermolecular distances and correspondingly smaller intermolecular attraction.

In the present investigation the method of nuclear magnetic resonance absorption is applied to the study of molecular motion in a number of pure organo-silicon compounds as well as in silicone polymers. Comparison of the observed proton absorption lines with those predicted by quantum mechanical theory indicates that there is an unusual amount of motion of the methyl groups in methyl silicones, but that this motion is confined in large part to rotation of the methyl groups about the carbon-silicon bond. The results point toward some modification of the free-motion theory, and should be useful in predicting the properties of related compositions.

Cosmic Ray Results on the New Unstable Particles

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In the last few years, cosmic-ray studies have revealed the existence of many new fundamental particles. Some of these particles are heavier than nucleons, some are lighter than nucleons but heavier than π-mesons. The names of *hyperons* and *heavy mesons* have been suggested to designate the two groups.

There is clear evidence for the existence of a neutral hyperon decaying into a proton and a negative π-meson, with a mean life of about 3×10^{-10} sec:

$$\Lambda^\circ \longrightarrow p^+ + \pi^-.$$

There are also strong indications for the existence of a charged hyperon decaying into a neutron and a charged π-meson:

$$\Lambda^\pm \longrightarrow n + \pi^\pm.$$

The existence of at least two different kinds of heavy mesons appears to be fairly well established. Among them there seem to be particles which decay into two π-mesons:

$$\theta^\circ \longrightarrow \pi^+ + \pi^-.$$

No definite statement can be made as yet concerning the decay scheme of the other neutral mesons.

The experimental situation concerning the charged heavy mesons is still very obscure. There certainly exists a charged heavy meson which decays into three π-mesons:

$$\tau^\pm \longrightarrow \pi^\pm + \pi^\pm + \pi^\mp.$$

There also are charged heavy mesons whose charged secondary products are single light mesons (π- or μ-mesons). In some cases, at least, photons are present among the decay products of these particles. The following decay schemes have been suggested:

$$\kappa \longrightarrow \mu + (2 \text{ neutral particles})$$
$$\chi \longrightarrow \pi + (1 \text{ neutral particle})$$

It is not known at this time how many different kinds of charged heavy mesons exist. One must consider the possibility that a given type of particle may have several alternate decay schemes.

Interpretation of High Energy Experiments

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Since the development of high energy accelerators which took place shortly after the war, a great deal has been learned of the behavior of matter in this new domain. Cosmic ray research too, by its discovery of many new particles, has revealed a richness of nature rather embarrassing to the physicist attempting to reach some further understanding. The successes of theoretical physics have been limited, and of a rather limited kind. They are based almost entirely on general, well founded, and unspecific principles, such as the conservation of energy, momentum, angular momentum, and parity. They thus have to do with the symmetry properties of the equations satisfied by nucleons and mesons, rather than with the explicit forms of the equations themselves, and still less with their explicit solutions. Experiments with low energy π-mesons strongly indicate the existence of an additional symmetry property: the principle of charge independence, which relates the behavior of charged and neutral mesons. For low energy mesons, the conservation laws so limit the available quantum states that a reasonable, if incomplete, picture of what goes on may be obtained. This is no longer true at the high energies of the Brookhaven Cosmotron, or of the cosmic rays, where the characteristic phenomena become the multiple production of mesons and the production of new types of particle. Pais is attempting to integrate the principle of charge independence more deeply into the theory in the hope of discovering the relationships between the many particles which may exist. Meanwhile, the more heuristic approach used by Fermi, based on phase space arguments familiar in statistical mechanics, is being actively pushed as a basis for the discussion of the rapidly developing experimental results.

Plastic Flow in the Cutting and Grinding of Materials

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While quantitative studies of cutting operations designed to improve the efficiency of metal removal operations are of considerable industrial importance, the results of such studies also yield information concerning the basic behavior of materials that is not readily obtainable from more conventional materials tests. Photomicrographs of partially formed chips reveal that ductile metals are normally cut by a process of shear flow that is confined to a relatively small volume of metal in the vicinity of the point of the tool. The smallness of volume deformed at any one time makes it possible to investigate the influence of specimen size upon flow behavior and at the same time to carry out tests at relatively high rates of strain. Cutting tests performed over a wide range of specimen size suggest that a size effect is generally operative in the plastic flow of materials. The size effect so readily evident in metal cutting will be shown to pertain to a lesser extent to the ordinary torsion test, to bend tests, and to microhardness testing. The size effect concept also explains the empirical rules of comminution of normally brittle materials. While this explanation lends to essentially the same relationships for the energy required to pulverize materials it focuses attention on the quantities that are physically responsible rather than on the relatively trivial concepts originally invoked by von Rittinger and Kick to explain grinding energies. From the new point of view the controversial rules of von Rittinger and Kick normally considered to be incompatible are found to hold for relatively large and small particle sizes respectively.

Experimental Results with the Brookhaven Cosmotron[1]

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The Cosmotron presently is capable of accelerating protons up to energies of 2.25 billion electron volts. When these protons are allowed to strike a solid target, beams of high-energy secondary particles can be produced. These particles and their interactions with matter are being investigated by means of scintillation counters, nuclear emulsions, and cloud chambers, by a number of groups. High energy neutrons and protons when colliding with another single proton appear usually to produce several π-mesons simultaneously. π-mesons, believed to be responsible for nuclear forces, are known as unstable particles whose mass is 276 times that of an electron (as com-

[1] Work performed under the auspices of the U.S. Atomic Energy Commission.

pared to 1840 electron masses for neutrons or protons). A study of their interactions with neutrons and protons, and with each other, should lead to a better understanding of the nuclear forces. π-mesons are capable of producing several other π-mesons in one collision. They have also been found to produce some of the heavy unstable particles so far found only in the Cosmic Radiation. This will enable one to investigate in detail the processes responsible for the production of these still rather mysterious particles which appear to decay into neutrons, protons, or π-mesons after living for only one-billionth of a second or less. Cloud chamber photographs illustrating some of the discussed processes will be shown.

Biochemical and Physicochemical Identification of Type II Human Poliomyelitis Viruses

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The development of a procedure for the purification of poliomyelitis virus from infected cotton rat central nervous system tissue in this laboratory has made possible the preparation of Lansing virus (type II) concentrates of unusual purity. The purification method which involves treatment with butanol and enzymes yields virus concentrates with an average specific infectivity 20,000-fold greater than that of the original infected tissue. The recovery of total virus infectivity under these conditions is approximately 50%.

Electron microscopy of these preparations utilizing the micro droplet technic reveals well defined, uniformly spherical particles 28 mμ in diameter plus irregularly shaped, flat masses of amorphous material which constitute approximately 90% of the total mass observed. In contrast parallel preparations of concentrates from uninfected tissue show amorphous material but no 28-mμ particles.

It has been possible to show by correlative studies involving analytical electron microscopy (direct particle counting in micro droplets), ultracentrifugal sedimentation through the barrier of a separation cell, and infectivity measurements that the property of infectivity resides solely in the 28-mμ particle.

By a similar purification method the MEF 1 strain of type II poliomyelitis virus has been obtained in a highly purified state from the nutrient fluid of infected cultures of monkey kidney tissue. Preliminary electron microscopic studies of these virus preparations reveal 28-mμ particles and virtually no amorphous material.

On the Brightness of Lights and the Loudness of Sounds

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Brightness and loudness are subjective attributes of visual and auditory sensation. Both attributes are functions of the energy of the physical stimulus, but they are not simple linear functions of energy. Nor are they proportional to the logarithm of the stimulating intensity, as was first asserted by Fechner, and as has been assumed by many others.

We have studied the relation of brightness and loudness to radiant and acoustic energy by three techniques: bisection, fractionation, and absolute judgment. These techniques require the subject to assess, in different ways, the apparent magnitude of his sensations, and although the results differ in detail they show sufficient agreement to warrant the construction of ratio scales for these subjective magnitudes.

There appears to be a remarkable similarity between the brightness scale and the loudness scale. Over most of the sensible range of intensities, the two scales are roughly a power function of the energy of the stimulus. To a crude first approximation brightness and loudness are proportional to the cube root of the stimulating energy.

Other striking similarities between brightness and loudness are also evident. For example, a sound is masked by noise much as a light is suppressed by glare, and the well-known phenomenon of "auditory recruitment" in which the loudness of a masked sound grows rapidly to normal as its intensity is raised has its analogue in vision. A light that is just invisible in the presence of a glare attains its normal brightness when its intensity is raised to a value equal to that of the glare itself.

The Excluded Volume Effect in Polymer Chains

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The fundamental question implied by the title is whether and how the average dimensions of real flexible long-chain molecules differ from those of the common idealized model based on the theory of random flights. In particular, how do the average dimensions depend on molecular weight of the chain? This question has been hotly debated in recent years. It has acquired considerable glamor because of its theoretical difficulty, but it also is of practical importance for the interpretation of intrinsic viscosity and certain other frequently studied properties of polymer solutions.

The random-flights model predicts that the mean square radius R^2 of the chain is proportional to its molecular weight M. On the basis of both experimental and theoretical studies we have joined the school which asserts that R^2 for real chains increases more rapidly than M, except in certain special solvents. For a series of linear polyvinyl acetate fractions covering the molecular-weight range 0.8 to 3.5 million, our light-scattering measurements show definitely that in butanone solution R^2/M is increasing with M. These results moreover support the simple and useful treatment of intrinsic viscosity proposed by Flory and Fox. Theoretically, one must be content with incomplete answers, but some rather general arguments can be given for the correctness of our conclusion. For example, it can be shown that if R^2/M depends on solvent (as it does experimentally) it must also depend on molecular weight.

Correlation of Rates of Solvolysis

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The solvolysis of an organic compound is its reaction with the solvent in which it is dissolved; this may be water, an alcohol, an acid, an amine, or a mixture. Absolute rates of solvolysis are difficult to correlate because of variations in kinetic energy or entropy terms in the free energy of activation, which do not in general parallel variations in the potential energy terms. The entropy terms appear to be effectively cancelled out if one compares only differences in logarithms of relative rates with the equation

$$\log (k/k^\circ)_A - \log (k/k^\circ)_{A^\circ} = ab$$

where k is the rate constant for solvolysis in any solvent, k° is the same in a standard solvent (80% ethanol-20% water), A refers to any organic chloride or bromide, A° to a standard compound (methyl bromide), a is a constant depending only on the compound, and b is a constant depending only on the solvent.

To test this equation, a total of 124 rate measurements was used, 62 measured in this laboratory and 62 from the chemical literature, representing 15 compounds and 19 solvents. Typical values of a (determined by the method of least squares, defining $a = 0.00$ for methyl bromide and 1.00 for t-butyl chloride) are -0.37 for p-nitrobenzoyl chloride, $+0.06$ for benzoyl chloride, $+0.18$ for n-butyl bromide, $+0.19$ for benzyl chloride, $+0.42$ for i-propyl bromide, $+0.78$ for benzhydryl chloride, and $+0.93$ for t-butyl bromide. Thus a increases with increasing electron supply to the carbon atom undergoing displacement. Typical values of b (defining $b = 0.00$ for 80% ethanol) are -17.3 for triethylamine, -9.66 for pyridine, -4.78 for aniline, -0.79 for ethanol, $+2.95$ for water, $+0.57$ for acetic acid, and $+4.00$ for formic acid. Thus b increases with both acidity and dielectric constant.

The maximum variation in the observed absolute rate constant k for any one compound over the range of solvents studied is a factor of 2.8×10^6. The maximum and mean errors in absolute k values calculated with the equation are factors of 7.6 and 1.5, respectively.

The Subunits of Myosin

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Myosin, the main contractile protein of muscle, is capable of violent structural changes and enzymic activities. It is composed of two components connected with peptide linkages (*1–4*). These subunits were called light-, and heavy-meromyosin corresponding to smaller and larger molecular weights. A single myosin molecule is made up of four light-meromyosins and two heavy-meromyosins. The important properties of myosin, probably connected with its function, are quantitatively retained by its subunits. The light-meromyosin has a strong tendency to form structures under different conditions and has solubility similar to myosin; the heavy-meromyosin has the total adenosinetriphosphatase activity of the intact myosin molecule and combines with the same amount of actin. The properties of myosin are not only additive and what is lost is contractility. In that respect the whole molecule is more than the sum of its components. It is probable that it is the light-meromyosin where active folding occurs in contraction. The possibility that contraction is a change in the relative position of larger units as opposed to a uniform change in the peptide chain at the amino acid level is discussed. The structure of the light-meromyosin is in accordance to such a theory being composed of about eight units of molecular weight of 6–8000 and still smaller components of two kinds. These are called protomyosins. They are connected mainly end-to-end to form the light-meromyosin.

References

1. Gergely, J. *Federation Proc.*, **9**, 176 (1950).
2. ———. *J. Biol. Chem.*, **200**, 543 (1953).
3. Mihalyi, E., Szent-Györgyi, A. G. *Ibid.*, **201**, 289, 211 (1953).
4. Szent-Györgyi, A. G. *Arch. Biochem. Biophys.*, **42**, 305 (1953).

A New Evaluation of the *Lucy Ashton* Ship Model and Full Scale Tests

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The British Shipbuilding Research Association has carried out extensive full scale and model resistance tests with the *Lucy Ashton*, the results of which have recently been published in a paper read before the Institution of Naval Architects by Conn, Lackenby, and Walker. A family of six geometrically similar models has been tested and extensive resistance tests have been carried out with the full size ship in an endeavor to supplement William Froude's classical "Greyhound" tests with modern extrapolation data. Although the importance of this B.S.R.A. enterprise can hardly be overestimated, there is a definite lack of model data in the low Reynolds' number field, because there are no facilities available in Great Britain to carry out experiments with 6- and 4-ft ship models with the required accuracy. Such facilities, however, are available at M.I.T. and experiments with two small ship models have been conducted to cover the low Reynolds' number field and to greatly extend the available data for extrapolation from the model family to the full size ship results, which in the formerly available range was lacking in definition. A complete revision of the extended data is presented and the merits of a new and original extrapolation method will be demonstrated.

Effect of Local Action Currents on the Iron Electrode

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The ideal metal electrode for electromotive force measurements is reversible with respect to its own ion species, but no others, and the potential change for a tenfold change of ion activity corresponds exactly to $0.0591/n$ volt at 25° C, where n is the valence of the ion. A few metals approach this behavior, but most metals deviate from the ideal in some degree. For example, an iron electrode is reversible to hydrogen ion in mild acid media, but the potential change for a tenfold change of ion activity can be equal to or less than 0.059/2 volt depending on the electrode and solution. The electrode is peculiarly unaffected by ferrous ions in the same pH range, but is reported to behave in a normally reversible manner in the pH range approaching 7 and above.

This behavior is explained in terms of local-action or corrosion currents operating whenever iron is in contact with an aqueous solution. All metal electrodes to some extent exhibit irreversible effects from this cause. For example, calculated local action currents decrease the reversible potential of cadmium amalgam electrodes, as used for standard cells, in the order of 10^{-6} volt, which is a small effect, but for iron and several other metals the deviation may reach several tenths of a volt. Local action currents for metal electrodes more active than hydrogen in the Electromotive Series always produce a shift of potential in the cathodic direction. The general expression is $E(\text{thermodynamic}) = E(\text{observed}) + f(i)$, where $f(i)$, a function of local action currents, can be calculated from polarization data.

Basic knowledge of the potential behavior of metals is important to various biological and medical techniques, as well as to fundamental electrochemical studies including corrosion of metals, and primary and secondary batteries.

X-Ray Studies of Imperfections in Solids

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The x-ray scattering from a crystal consists of two parts: the sharp Bragg reflections, and the diffuse scattering. The Bragg reflections give the average crystalline structure of the material: information such as the size and shape of the unit cell and the average positions of the atoms within the cell. Any sort of randomness or disorder in the structure produces a diffuse scattering in addition to the sharp Bragg reflections, and it is only from measurements of this diffuse scattering that precise information about the state of disorder can be obtained. The study of the imperfections in real solids is a new and rapidly growing branch of x-ray diffraction analysis. Three types of disorder will be illustrated and discussed.

(a) From the diffuse scattering of x-rays by the temperature vibration of the atoms, it is possible to obtain the elastic spectrum of solids, including the frequency distribution, the velocities of the elastic waves and the dispersion at high frequency.

(b) A disordered binary alloy gives rise to a diffuse scattering due to the random arrangement of the two different kinds of atoms. A Fourier analysis of the diffuse scattering gives directly the short range order parameters of the alloy.

(c) Cold work distortion in a metal produces broadened and displaced peaks in the x-ray diffraction pattern. Fragmentation, random strains and stacking faults all contribute to the observed diffuseness of the pattern. By separating the effects and evaluating each of them, a clear picture of the nature of the cold worked state is beginning to develop.

The Stereochemistry of Deuterium Transfer in Enzymatic Oxidation-Reduction Requiring DPN+

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By the use of deuterium as a tracer, it has been possible partially to elucidate the mechanisms of those oxidation-reduction reactions which require the coenzyme diphosphopyridine nucleotide (DPN+). The reactions investigated in our laboratories, and more recently elsewhere, include those catalyzed by yeast alcohol dehydrogenase, liver alcohol dehydrogenase, lactic dehydrogenase, and a transhydrogenase; in addition, a model system (N-benzyl dihydronicotinamide plus malechite green) has been examined. In all of these reactions, there is a direct transfer of hydrogen (or deuterium) between substrate and coenzyme (or coenzyme model). For example,

$$CH_3CD_2OH + DPN^+ \rightarrow CH_3CDO + DPND + H^+ \quad (1)$$

When DPND (eq. 1) is used to reduce acetaldehyde, the monodeuteroethanol so produced consists of one pure enantiomorph; the other enantiomorph has been prepared by the reduction of deuteroacetaldehyde with ordinary reduced DPN+. Although neither enantiomorph has been obtained in large enough quantity for a polarimetric determination of its specific rotation, the individuality of the stereoisomers has been proved by observing the specific products of their enzymatic reoxidation. Furthermore, it has been possible to perform a stereochemical inversion of one enantiomorph into the other.

The enantiomorphic ethanols can be used both to elucidate the steric requirements of organic chemical reactions around a primary carbon atom, and to investigate the stereospecificity of the direct transfer of deuterium in enzymatic reactions of DPN+.

Carbohydrate Supply and Leaf Development in Sporeling Ferns

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In nature, the sequence of leaves on young ferns proceeds regularly from the initial two-lobed type to the three-lobed and then on to the characteristic pinnate or feathered adult fern leaf. Before any adult leaf appears, 15–20 two-lobed and three-lobed types arise. So regular is this pattern that classical botanical studies on ferns have referred to it as recapitulatory. When grown *in vitro* on a constant, sterile medium containing 2% sucrose, young fern plants follow the same natural sequence. Moreover, when only pieces of the stem apex, 0.25 mm in height, are similarly planted *in vitro*, this same sequence of leaf types still occurs.

A study *in vitro* of the effect of a varying sugar concentration in an otherwise constant medium has shown that profound changes occur in leaf shape. The effective differences in concentration range from 0.1% to 2%; above this no appreciable effect is found. At lower concentration, the first twenty or more leaves are two-lobed; only after such a number does a first three-lobed type develop. On media containing 1% and 2% sucrose, leaves produced on explanted apices have predominantly three or more lobes. At concentrations in between, interesting plants occur with unpredictable ratios of two- and three-lobed leaves.

In leaves, shape is determined by the relative persistence of meristematic activity along the margins and at the apex. Two-lobed leaves, resulting largely from marginal extension and from scarcely any terminal cell divisions, have a heart-shaped appearance, a small photosynthetic surface and little or no root for an absorbing surface. If the concentration is increased, more sugar is absorbed supplementing that obtained by photosynthesis. A direct relation early becomes apparent between the concentration of sugar in the medium and the extent of cell division in the leaf. Marginal meristematic activity, supplemented by apical cell division, forms a three-lobed leaf or a pinnate leaf depending upon the concentration of sugar available.

The results reported here accord with Bullough's findings on the carbohydrate energy relations of cell division in the *in vitro* studies on ectoderm of mouse ears. Certainly it is difficult to see a phylogenetic recapitulatory sequence in it.