National Academy of Sciences

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Certain Fundamental Events in the Menstrual Cycle

The generally accepted concept of the menstrual cycle is based on R. Schröder's studies of human uterine mucous membrane. Since normal human ovaries are rarely available, he used this target organ for seriation. Form changes in the glands were stressed and interglandular stroma neglected. Actually cyclic changes in the stroma influence the form of both glands and blood vessels. A superficial resemblance between the entire mucosa of late menstrual stages and the basal zone of other phases led him to believe that most of the mucosa is shed during menstruation. Assuming extensive postmenstrual regeneration, he emphasized mitoses in glands ("proliferative phase"), although mitoses in the stroma are not correspondingly abundant.

The study of monkeys with cycles essentially similar to human cycles has added materially to the understanding of the changes. Both ovaries and the uterus from a sufficiently large number of normal animals can be serially sectioned and seriated on the basis of ovarian developments, as Corner was the first to do. Adequate technical methods demonstrate dedifferentiation of stroma and arteries superficially resulting from vasoconstriction before and during menstruation. Loss of tissue fluids and reduction in cell size contribute more to the thinning of the mucosa than does the shedding of tissue. In the phase of repair, the restoration of stromal ground substance plays the major role.

Schröder's "secretory phase" was based largely on the enlargement and dilatation of glands by accumulated secretion. The production of secretion reaches its height during this phase, but the gland cells are active throughout the cycle. The difference is that in other phases the secretion is extruded and not stored. This can be correlated with differences in the activity of the myometrium.

GEORGE W. BARTELMEZ
Carnegie Institution of Washington, Baltimore

Gallium: Thermal Conductivity; Supercooling; Negative Pressure

And Gallio cared for none of those things. Acts 18: 17.

Gallium is a nonconformist among metals. It melts at 29.8°C, but its boiling point is about 2000°C. On cooling, it shows an utter disregard of its melting point and can be supercooled to −28°C without freezing, or 58°C below its melting point. Like water, it expands on freezing. In appearance, liquid gallium greatly resembles mercury.

The thermal conductivity of liquid gallium does not appear to have been previously measured. The method employed was a modification of that proposed by Benjamin Franklin and first used by Ingenhautz (1789) for comparing the thermal conductivity of two metal bars. Two glass tubes (30 cm long, 10-mm bore, 1-mm wall) were filled with pure mercury and gallium and were sealed. The upper ends of these tubes were inserted vertically through the bottom of a water boiler equipped with a heating coil, condenser, stirrer, and thermometer. The tubes were coated with a nonmetallic paint to insure the same thermal emissivity. Thermojunctions of fine wire that could be slid along the tubes served to establish points of equal temperature.

The relative thermal conductivity is theoretically equal to the *square* of the ratio of the distances of the two thermojunctions from the bottom of the boiler. The squared ratio of gallium to mercury was found to be 3.50 ± 0.05 or 0.081 cal/sec-cm-°C, computed from the known value of mercury at 60°C.

Supercooling was carried out by exposing droplets of liquid gallium on a sheet of paper in a slowly cooling deep-freeze chamber, equipped with a fan. Freezing was established when the spherical drops could no longer be distorted by a fine glass probe. The maximum supercooling observed was −28°C, or 58°C below its melting point.

The attempt to measure the negative pressure sustained by gallium was disappointing. To sustain a negative pressure, the liquid must adhere to the walls of the container. Although gallium clings tenaciously to a glass surface carrying an adsorbed layer of air, it does *not* wet the tube when the gas is removed. By partial pumping to retain some adhesion, it was found that, like water, the negative pressure decreased as the melting point was approached.

LYMAN J. BRIGGS
National Bureau of Standards

Effect on Endosperm Phenotype in Maize of Heterozygosity at the R Locus in the Staminate Parent

Normally, the gametes A and A′ arising from an AA′ individual, considered as a generalized monofactorial heterozygote, are precisely equivalent in their effects on the offspring to the corresponding gametes formed by the respective homozygotes, AA and A′A′. This rule was found not to hold in maize testcrosses involving an *R* allele (self-colored aleurone) and R^{st} (stippled aleurone).

A single RR^{st} plant, in a relatively uniform inbred strain, was self-pollinated. Pollen of the three classes of offspring, *RR*, RR^{st}, and $R^{st}R^{st}$ (distinguishable also by anther color) was placed on a highly inbred *rr* (colorless aleurone) stock. A determinate area of aleurone on each kernel then was scored quantitatively for pigmentation. Modal color grades (scale of 0–100) of the kernels on representative ears from the $rr♀ \times RR♂$ and $rr♀ \times R^{st}R^{st}♂$ matings were 98 and 23, respectively. The $rr♀ \times RR^{st}♂$ testcross gave a bimodal distribution with well-defined peaks at 3 and 18–23.

Verification of kernel genotype in the latter testcross requires a progeny test. It is obvious, however, that the score (3) for one kernel class, at least, derived from the heterozygote differs greatly from the value for the corresponding homozygote. Since the *RR* and $R^{st}R^{st}$ genotypes tested were offspring of a selfed RR^{st} plant, the change in endosperm phenotype associated with the heterozygosity appears to be transitory.

R. ALEXANDER BRINK
University of Wisconsin

Influence of Fluid Motions on the Free Decay of a Magnetic Field

The influence of fluid motions on the free decay of a magnetic field is investigated. It is shown that with suitable velocity fields the time constant for decay can be reduced or increased by large factors. Examples illustrating this phenomenon are worked out in detail; and applications to the problem of the origin of the earth's magnetic field and the growth and decay of the magnetic field of a sunspot are suggested.

S. CHANDRASEKHAR
Yerkes Observatory, Williams Bay

Duodenal Ulcer and the Hypothalamus-Pituitary-Adrenal Stress Mechanism

The fasting hypersecretion of gastric juice in duodenal ulcer patients has been attributed by us to excessive secretory activity of the vagus nerves. Recently, Gray and French have postulated an extravagal mechanism whereby stress produces a hypersecretion of gastric juice with ulcer formation. The hypothalamus is believed to be stimulated by mental and physical stress, and this, in turn, stimulates the pituitary and adrenal cortex. Cortisone, the end-product of this series of reactions, then acts directly on the gastric glands, producing a hypersecretion of hydrochloric acid. The experimental and clinical evidence presented in this paper fails to support these concepts.

The fasting nocturnal gastric secretion in a series of duodenal ulcer patients was measured three or four times previous to operation and then daily for the first 5 days after vagotomy and gastroenterostomy. In many patients an exaggeration of the usual hypersecretion of gastric juice occurred on the night before surgery, possibly owing to anxiety concerning the approaching operation. During the first 5 days after the operation, however, the fasting secretion remained below the level found in normal people in all cases. It is thus evident that this hypersecretion is abolished by vagotomy and that the release of cortisone by the trauma of the operation is not sufficient to stimulate the gastric glands.

In the laboratory Heidenhain pouches devoid of vagus innervation were prepared in dogs, and after control measurements of gastric secretion, artificial states of stress were produced by injecting insulin, epinephrine, cortisone, and ACTH. Even in large doses, no stimulation of secretion occurred. It is concluded that the fasting hypersecretion of gastric juice in duodenal ulcer patients is of vagus origin and is not due to the liberation of cortisone.

LESTER R. DRAGSTEDT, HERZL RAGINS, LESTER R. DRAGSTEDT II, SHIRL O. EVANS
University of Chicago

Effect of Temperature on the Long-Wave Limit of Photosynthesis

Measurements made by Emerson and Lewis [*Am. J. Botany* **30**, 165 (1943)] at 10°C showed a sharp drop in the efficiency of *Chlorella* photosynthesis in the wavelength region just beyond 685 mμ. The results shown in their Fig. 5 indicate that at 700 mμ the efficiency was less than half the value at 685.

Our measurements show that at higher temperatures the decline begins at shorter wavelengths than at lower temperatures. For example, at 20°C we have observed a 50-percent drop in efficiency between 650 and 685 mμ, while at 5°C the efficiency remained nearly constant from 650 to 685 mμ, and the 50-percent drop came between 685 and 710 mμ.

We have found this temperature dependence of the long-wave limit of photosynthesis with both *Chlorella pyrenoidosa* and *Porphyridium cruentum*. However, it seems to be characteristic of low intensities of light. If the low-intensity light beam of measured energy is supplemented by a more intense (unmeasured) beam, then the efficiency of the small increment of measured light remains nearly constant out to 685 mμ, even at a temperature of 26°C. The supplementary beam is effective whether it is made up of a mixture of longer and shorter wavelengths, or whether is includes only red light of wavelengths longer than 650 mμ.

Blinks and Haxo [*J. Gen. Physiol.* 33, 389 (1950)] observed that with algae containing phycobilin pigments the efficiency at 685 mμ was low. From this they concluded that in these organisms the light absorbed directly by chlorophyll was relatively ineffective in photosynthesis. We suggest that at the temperature of their experiments, 685 mμ may have been beyond the long-wave limit for full efficiency at low light intensity. Our measurements with *Porphyridium* indicate that at shorter wavelengths the efficiency of light absorbed by chlorophyll is normal.

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ROBERT EMERSON, RUTH CHALMERS, CARL CEDERSTRAND, MARCIA BRODY
University of Illinois

Restricted Random Walk in Transport

Einstein found for the diffusion coefficient D and viscosity η the relationship

$$D\eta = \frac{kT\,dlu\ a}{6\pi r\,dlu\ c} \qquad (1)$$

It was obtained by equating the Stokes hydrodynamic equation for the force on a sphere to the negative of the gradient of the thermodynamic potential. For self-diffusion, one finds by relaxation theory for the viscosity, $\eta = kT/\lambda^3 k'$ and for the diffusion coefficient

$$D = \frac{\lambda^2 k'}{\zeta}\,\frac{dlu\ a}{dlu\ c}$$

Whence,

$$D\eta = \frac{kT}{\zeta\lambda}\,\frac{dlu\ a}{dlu\ c} \qquad (2)$$

k, T, r, λ, c, a, k', and ζ are the Boltzmann constant, absolute temperature, radius of the sphere, lattice spacing, concentration of diffusing particles, their activity, frequency of forward jumping by a lattice distance, and the number of viscous shearing motions required to advance a diffusing molecule one lattice distance, respectively.

As is anticipated, ζ comes out near 6 for normal liquids. This corresponds to the number of nearest neighbors in the same plane in hexagonal close packing. The diffusion coefficient $D\zeta$ for the center of gravity of a cloud composed of ζ independently diffusing molecules is likewise

$$D_\zeta = \frac{\lambda^2 k'}{\zeta}\,\frac{dlu\ a}{dlu\ c} \qquad (3)$$

where

$$D_1 = \lambda^2 k'\,\frac{dlu\ a}{dlu\ c}$$

is the diffusion coefficient of a single molecule. Thus, a long flexible molecule composed of ζ kinetic segments should obey the relationship $D\zeta = D_1/\zeta$. Here, D_1 is the diffusion coefficient of a kinetic segment and $\zeta \approx M$, whereas for the compact sphere of Einstein $D \approx M^{-1/3}$ where M is the molecular weight. The viscosity of complex liquids can be expressed by

$$\eta = \sum_i \frac{\chi_i \beta_i}{\alpha_i}\,\frac{sinh^{-1}\beta_i \dot{s}}{\beta_i \dot{s}}$$

where χ_i, β_i, α_i and $\dot{s}$ are the fraction of the shear surface covered by the ith units, the relaxation time, the reciprocal of an intrinsic pressure, and the rate of shear, respectively. These parameters are predictable from structure.

HENRY EYRING, TAIKYUE REE, THEODORE EINWOHNER
University of Utah

Brain Fuel and Function

The central nervous system, according to current thought, normally obtains its energy, for maintaining integrity and for active function, by burning sugar with oxygen. The energy is presumably fed into the cell machinery via high-energy phosphate esters. Recent work with Abood showed that the well-known fall in concentration of these esters during activity is—for muscle, nerve, brain, and brain mitochondria—more a result of decreased synthesis than of increased breakdown and, therefore, does not represent a quick energy release.

We have found that perfused brain (cat) can continue active, can even be convulsed, with no use of extrinsic or intrinsic carbohydrate sources; indeed, convulsions are possible with no increase in oxygen consumption, much as conduction in azide-poisoned nerve continues without increased oxidations. In perfused or normal brain, moreover, activity evoked by convulsive drugs or currents or by afferent nerve stimulation is associated with a breakdown of lipo- and nucleoprotein, which is associated with a reversible decrease in microsomes, and an increase of amino nitrogen in the effluent. The perfused brain gradually fails to take up glucose, produces much lactate, and fails in electric and reflex action. Addition of nucleic pyrimidines, particularly uridine and cytidine, like inclusion of liver in the perfusion circuit, prevents or reverses these changes and replenishes the galactosides and phosphatides that had earlier decreased. These nucleosides also prevent or reverse the loss of function and severe vasoconstriction produced by ATP addition. The catalytic action of uridine on galactose formation and of cytidine on that of phospholipids is relevant to their role in relating fuel to function in brain.

R. W. GERARD
A. GEIGER
University of Michigan

Mechanism of Growth Control in Liver Regeneration

Tissue-culture studies have shown a comparable outgrowth in a high concen-

tration of serum from partially hepatectomized rats and in a low concentration of normal serum. A high concentration of normal serum showed inhibitory effects. These findings were considered to indicate an inverse relationship between the concentration of certain serum constituents and liver growth [Glinos and Gey, *Proc. Soc. Exptl. Biol. Med.* **80**, 421 (1952)].

Evidence *in vivo* supporting this concept was obtained by showing that cell division can be induced in the resting liver by lowering the concentration of serum constituents through plasmapheresis and can be inhibited in the regenerating liver by increasing the concentration of serum constituents through fluid intake restriction. Electrophoretic analysis of serum proteins, undertaken as a first step toward identification of the serum constituents involved, showed decreased albumin concentrations when liver cells were dividing and normal or increased concentrations when cell division was inhibited. Histochemical investigation of the organization of cytoplasmic ribonucleoprotein in the regenerating liver showed changes beginning within 30 minutes after partial hepatectomy.

The changes are indicative of increased protein synthesis and proceed from the periportal to the centrilobular areas. Cell division follows the same topography but with a lag of from 16 to 24 hours. The nature of these changes and their spatiotemporal distribution suggest that postoperative local circulatory factors accelerate and accentuate the appearance of concentration changes in the interstitial fluid similar to those in the serum.

These observations lead to the conclusion that a negative feedback system operates in controlling liver regeneration. Further plans for elucidating the possible participation of albumin and the role of the interstitial fluid in the system, as well as the relationship of such a mechanism to Weiss' concepts of growth control, are discussed.

André D. Glinos
Walter Reed Army Institute of Research

Heat Conductivity in Polyatomic Gases

The assumptions implicit in the Eucken relation for the thermal conductivity of a polyatomic gas are discussed. It is found that under ordinary conditions it would be more reasonable to take for the correction for the internal degrees of freedom of the molecules the factor (2/5) $((C_v/R)+1)$ at very high temperatures. A generalization of the Eucken relation is given to take into account dissociative equilibria and the variation of the collision diameter of the molecules with electronic excitation.

Joseph O. Hirschfelder
University of Wisconsin

Induction of Normal Structures in Embryos and of Tumors in Larvae of Amphibians

A crucial question in embryology is to what extent external stimuli specify biological reactions. Is it the specificity of the stimuli or rather the selectivity of response of the organic systems that determines the outcome? This question becomes acute in instances such as egg activation, embryonic induction, and carcinogenesis. Normally, egg development is initiated by the sperm; neural and other structures are induced by adjacent tissues; some cancers can be correlated with specific genes. However, any one of these phenomena can be equally well produced by applying physical or chemical stimuli. The complexity of the situation is indicated by the following facts. (i) One and the same stimulus may have entirely different effects, varying with the age of the treated organism. (ii) Many, quite unrelated, stimuli may elicit the same biological response when applied to the same developmental stage.

In an attempt to clarify these problems, experiments were performed using well-known carcinogenic chemicals as stimuli and different developmental stages of amphibians as reactors. When they were acting on early embryonic stages, the implanted carcinogens induced the formation of normal structures, such as ear vesicles, adhesive glands, pronephric tubules; but when they were acting on larval stages, they initiated cancerous growth of various kinds. Obviously the kind of morphogenic response is determined by changes of competence of the reacting tissues rather than by the kind of artificial stimuli applied. Emphasis must be placed on investigation of the reacting time-space controlled biological systems rather than on the initiating stimuli which in a merely remote sense control development.

Johannes Holtfreter
University of Rochester

Mumps and Newcastle Virus Reproduction

Mumps and Newcastle virus particles can be counted by enumeration procedures developed in this laboratory for influenza A and B viruses. Each virus is adsorbed by erythrocytes; the number of particles that have the hemagglutinating property can be determined photometrically. One particle of each can infect; the number of infective particles can be determined in embryonated eggs. Under controlled conditions, preparations of each virus are obtained with hemagglutinating to infective particle ratios approaching 1.0. Electron microscope counts correspond with the number of hemagglutinating particles.

The infective property of mumps, like that of influenza A and B viruses, is unstable; the half-life is about 80 minutes at 35°C. Newcastle virus is less unstable; at 35°C the half-life is about 10 hours. The hemagglutinating property of the four viruses is relatively stable; with each the half-life at 35°C is longer than 16 hours.

New particles of mumps virus are not released before 24 hours. With Newcastle, as with influenza A and B viruses, new particles appear in less than 3 hours. With mumps, during the constant phase of logarithmic increase, the time to double the number of particles is about 15 hours, while with Newcastle, influenza A and B viruses it is about 45 minutes. The maximal yield of mumps per allantoic cell is about 50 particles, but with Newcastle, influenza A and B viruses it is about 1000 particles.

Initial particle-cell ratios of 3 or more cause alterations in the reproduction of mumps, influenza A and B viruses. Most striking is the emergence of a high proportion of hemagglutinating but noninfective particles. This does not occur with Newcastle virus, even when the initial particle-cell ratio is 40.

Frank L. Horsfall, Jr.
Rockefeller Institute for Medical Research

Endocrine Influences on Growth of a Benign Transplantable Mammary Tumor

This mammary adenofibruma consisting of an interlacing canal system of mammary ducts is unique among the experimental mammary tumors in that its growth rate can be enhanced or depressed by appropriate endocrine modifications. The rate of growth is uniform and vigorous in intact female rats and is depressed by ovariectomy.

Experiments were conducted on its growth in hypophysectomized rats in which the tumor grows slowly and progressively. Its growth is not stimulated by estrone, progesterone, or by the lactogenic or growth hormones of the pituitary, administered separately. Estrone and progesterone in combination moderately elevate its growth rate; supplementing these steroids with growth hormone restores the growth rate of the tumor to that occurring in intact females, whereas lactogenic hormone is ineffective in this regard.

Charles Huggins
Yolanda Torralba
Anna Charr
University of Chicago

Solutions for the Propagation of Waves through a Lattice of Spherical Scatterers

Solutions are obtained for the multiple scattering of waves in a lattice of scattering spheres. It is assumed that the index of refraction (or the potential, for electron waves) depends only on r inside each sphere and is constant between the spheres and that all spheres are equivalent, of radius a. Use of Green's theorem and the requirement that the solution at the nth sphere be $\exp(i\mathbf{K}\cdot\mathbf{R}_n)$ times the solution at the sphere at the origin leads to a rapidly convergent set of simultaneous equations for the coefficients F_{ml} of the expansion of the wave function at the spherical surface in spherical harmonics Y_{ml}. From these coefficients the nature of the wave inside and between the spheres can be computed. Roots of the related secular equation give allowed values of k^a (the electron energy or the acoustical frequency squared) as func-

tions of the vector **K**. The advantage of this formulation is that the secular equation relates two separated sets of functions: (i) the usual phase angles $\delta_l(k)$ for scattering from a single sphere, which depend only on the spheres' interiors and not on the lattice; (ii) a new set of functions M_{ml} (**K**, k) that depend only on the lattice and not on the spheres' interiors. Tables of the M's are being computed by machine for simple cubic and for face and body-centered cubic lattices, for different magnitudes and directions of **K** and different values of k^a. As functions of the propagation vector **K**, they exhibit the typical periodicity of the Brillouin zones; they have simple poles at $k^a = |\mathbf{K} + \mathbf{K}_\nu|^2$ where $\mathbf{K}_\nu$ is the νth vector for the reciprocal lattice. Solutions for the lower Brillouin zones can be obtained graphically. A few examples will be given of how the solutions change with **K**, with the ratio between a and the lattice spacing and with changes in the index of refraction (or electronic potential) inside the spheres.

PHILIP M. MORSE
Massachusetts Institute of Technology

Eohelea Stridulans, a Striking Example of Paramorphism in a Baltic Amber Gnat

Examples of similar structures in widely separated and quite unrelated animals, suggesting independent, parallel development along the same lines, are numerous and have been often discussed. The case of *Eohelea stridulans* is especially interesting, because it is unique in the order Diptera, whose members lack organs of stridulation and produce sounds in a totally different manner. *Eohelea* is the first representative of Diptera ever found that possesses stridulating organs comparable to those common in such Orthoptera as crickets and katydids.

As in species of *Ephippigera,* in which an almost identical stridulating apparatus is present on both forewings, *E. stridulans* has also a similar apparatus on both wings. But whereas in crickets and katydids the apparatus is situated near the base of the wing, in *E. stridulans* it is at the end of it. It is composed of 15 parallel ridges having a series of short, lateral branches on each side of each ridge. From the position of the ridges on the wings, one must conclude that the sound is produced by friction, not of the ridges themselves, but of these lateral branches. This excludes a homology between the sound-producing organs of Orthoptera and those of *Eohelea,* which also lacks a localized vibrating membrane or tympanum.

Since Orthoptera are very distantly related to Diptera, it is certain that the unique case of a stridulating apparatus in *Eohelea* developed independently. It seems probable that such development may take place when the prerequisite mechanical and physicochemical building stones are available so that the process may be started by some casual stimulation, while the completed structure is a result of the adequacy of its function.

ALEXANDER PETRUNKEVITCH
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Role of Structural Defects on Some Properties of Semiconductors

Properties of semiconductors can be greatly influenced by very small concentrations of chemical impurities and structural defects. For this reason, rigid requirements are placed on the degree of perfection in semiconductor crystals for research and for use in devices.

In this paper, a brief account will be given of some recent work directed toward evaluating the role of primary structural imperfections and their interactions on some properties of semiconductors. The discussion will include the origin and control of edge dislocations in the growth of silicon and germanium crystals from the melt, and the effect of variations in the density of this imperfection on carrier lifetime, some mechanical and surface properties, and on the kinetics of copper precipitation in germanium. Some discussion will also be devoted to radiation damage effects induced by electrons in crystals of germanium, silicon, and cadmium sulfide and the removal of these effects by annealing.

F. D. ROSI
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Origin of the Magneto-Ionic Expander Isotope Separator

The magneto-ionic expander followed 13 years of unsuccessful development of the ionic centrifuge, a form of isotope separator similar to the calutron, or the mass spectrometer. Unlike these devices, which operate at inherently high voltage, more than 50,000 volts for uranium, and which are unstable at woefully low currents of ions, the magneto-ionic expander operates at an effective voltage of less than 100 volts and has no current instability whatsoever. It offers isotopes of metals on a large scale less expensively than any other method I know of.

The manner of failure of the ionic centrifuge is instructive. A short electric arc is drawn between metallic electrodes in a parallel magnetic field and subjected to a negative perpendicular radial electric field. No negative electrons should move against this field. No positive ions should reach a cylinder at the radius r, until the potential reaches the Larmor value at r,

$$V(r) = -\frac{e}{mc^2} H^2 r^2$$

m being the mass of the positive ion. V could then be chosen so that only the ion of larger mass would be caught.

But the facts were otherwise. Negative electrons do travel out against the opposing electric field, even to an *insulated* cylinder at r. The negative potential of such an insulated cylinder will rise until it reaches the Larmor value; it receives approximately one-half of the total current of positive ions, plus electrons; the impoverishment of its deposit is less than $\delta m/2m$ irrespective of the magnitude of V. These facts led to the magneto-ionic expander isotope separator.

JOSEPH SLEPIAN
Westinghouse Research Laboratories

Dielectric Relaxation Times and Shapes of Rigid Molecules

The dielectric constants and losses of a number of liquids composed of rigid molecules have been measured at microwave frequencies and used to calculate the molecular relaxation times. The values thus obtained are combined with those already in the literature to study the effects of liquid viscosity, molecular size and shape, and dipole orientation in the molecule upon molecular relaxation time.

The results show a tendency of the molecular relaxation time and the viscosity to increase with increase in molecular size in a pure liquid and of the relaxation time to increase with viscosity, as required by the Debye theory. However, many exceptions to this tendency occur, and it is possible that apparent increase in relaxation time with viscosity is simply the result of increase in molecular size, which also increases the viscosity.

Although the attachment of a methyl group to a ring may not impede viscous flow and may even facilitate it, its protrusion impedes the molecular rotation necessary for orientation in an applied field and thus lengthens the relaxation time. The orientation of a dipole in an unsymmetrical molecule determines the most probable direction of rotation of the molecule and thus influences the relaxation time. When polar molecules are surrounded by nonpolar, their relaxation times are influenced by the nature of the nonpolar molecules as well as by the viscosity of the liquid as a whole. If the polar molecules are nearly spherical, the effect of the liquid viscosity is small.

CHARLES P. SMYTH
Princeton University

Histocompatibility Genes

Tissues grafted between identical twins or members of an inbred strain (isografts) are accepted by the host; tissues grafted between nontwins or from one inbred strain to another (homografts) are almost always resisted by the host and are usually rejected. Resistance to homografts is due to genetic differences between donor and host. The genes concerned are called histocompatibility genes.

Methods have been devised for the analysis of histocompatibility genes in the mouse. One method involves the use as "markers" of known genes linked with histocompatibility genes. A second method, involving a greater investment of time but having wider applicability, depends on the production by an appropriate series of crosses of isogenic resistant lines. These are lines identical with standard inbred strains except for the substitution at one locus of a gene causing resistance to grafts from the inbred strain. The isogenic resistant line and its inbred mate constitute a coisogenic pair, essentially identical except for a difference at one histocompatibility locus. By appropriate crosses, followed by inoculation of the hybrid with a suitable transplant (transplantable tumor), the gene differentiating the members of any coisogenic pair can be determined.

Three histocompatibility loci have been identified, *H-1* on chromosome I, *H-2* on chromosome IV, *H-3* on chromosome V. Eleven alleles (or pseudoalleles) are known at *H-2*. *H-1* and *H-3* are "weaker" than *H-2*; skin grafts between coisogenic strains differing at *H-1* or *H-3* survive longer than similar grafts between strain pairs with an *H-2* difference (Counce and Snell).

GEORGE D. SNELL
Roscoe B. Jackson Memorial Laboratory

Calculating the Loudness of Noise

The calculation of the apparent loudness of a complex noise from measurements of sound pressure levels in octave bands depends on the solution of three problems: (i) how loudness varies with the intensity of a sound; (ii) how loudness varies with the bandwidth of the spectrum; (iii) the form of the equal loudness contours for octave bands of noise.

The subjective loudness of a 1000-cycle tone and of bands of noise of medium and high frequency increases as a power function of the physical intensity of the sound. The loudness in sones, S, is related to the level in decibels, P, by the formula, $\log_{10}S = 0.03P - k$, where k is a constant. The loudness of low-frequency sounds grows more rapidly with level.

When equally loud octave bands are combined to form a wide-spectrum noise, the over-all loudness is a linear function of the number of bands. When unequal bands are combined, the total loudness S_t of a complex noise is given by

$$S_t = S_m + 0.3(\Sigma S - S_m)$$

where S_m is the loudness of the loudest octave band and ΣS is the sum of the loudnesses of all the bands.

From a determination of the form of the equal loudness contours for octave bands of noise, a chart has been constructed to relate the loudnesses of the several bands to sound pressure level. By means of this chart, physical measurements of a sound spectrum can be converted to loudness per octave band, and from these loudnesses the total loudness of the noise can be computed by the foregoing equation. This loudness in sones can be converted to loudness level in phons by the formula, $\log_{10}S = 0.03P - 1.2$.

S. S. STEVENS
Harvard University

Radiometry of Mars and Venus

This paper reports the distribution of infrared emission over the face of the planets and their spectra, both measured in the spectral region to which our atmosphere is relatively transparent, 8–14 μ. The scanning spot was 1.4 seconds in diameter, while the spectra of radiations from the disk as a whole exhibit 0.1-μ resolving power. Local black bodies served to calibrate radiometer response; and measurements on the moon served to account for our atmospheric transmission.

Both dark and sunlit hemispheres of Venus were at approximately −40°C. The local noon temperatures on Mars were 25°C for light areas and 33°C for dark areas. Minimum night temperatures are estimated as −70°C.

Equatorial scans across Venus in 1953 gave a slope of 5° per diameter of the planet across the evening terminator, and 1954 measurements across the morning terminator indicated a reversed slope and a direct sense of planetary rotation as a consequence, but the measurements of 1954 do not conclusively establish it.

Scans across Mars show a maximum temperature ½ hour after noon, indicating a surface thermal diffusivity higher than that of the moon but not as high as loam on the earth.

Spectra of Venus and Mars are dominated by telluric absorption. When reduced to outside our atmosphere, neither spectrum reveals any strong features, such as might be expected from the bands at 9.4, 10.4, and 12.6 μ, owing to the great CO_2 content of Venus.

We are grateful to I. S. Bowen for granting us use of the California telescopes; and we acknowledge Office of Naval Research support.

JOHN STRONG
WILLIAM M. SINTON
Johns Hopkins University

Phototropism of the Avena Seedling in the Ultraviolet

Avena sativa seedlings curve toward a source of ultraviolet light with a response that is not limited to the tip but is distributed over the whole seedling. Irradiation of limited zones shows that maximum sensitivity occurs in the region below the tip and around the mesocotylary node. The curvature is proportional to the logarithm of the applied energy. Its action spectrum shows a peak at 297 mμ with a shoulder at 280 mμ, and a trough at about 260 mμ. This excludes the participation of riboflavin as a detecting pigment in these curvatures. The significance of the action spectrum will be discussed.

KENNETH V. THIMANN
GEORGE M. CURRY
Harvard University

Hydrogenase in Biological Nitrogen-fixing Agents

Hydrogenase from *Clostridium pasteurianum* has been purified from the "soluble" fraction (supernatant from centrifugation at 144,000 × g of the material obtained after disintegration of the cells). Examination of the most purified material in an analytic centrifuge revealed a major and minor component. The enzyme was estimated to be about 80-percent pure; the spectrum contained a pronounced flavin peak. A partially purified preparation subjected to electrophoresis at *p*H 7.0 in 0.05*M* phosphate possessed 14 components, two of which contained flavin. One of these contained all the hydrogenase activity.

Difference spectra of whole cells of *Azotobacter vinelandii* established that H_2 will reduce intracellularly pyridine nucleotides, flavins, and cytochrome components, and that N_2 will oxidize a cytochrome-*b*-like pigment and a flavin. Hydrogenase in the azotobacter is particulate; attempts to purify it sufficiently to make studies similar to those that have been so revealing with the clostridial enzyme have been only partially successful. Application of methods for fractionation of mitochrondia provided a fraction containing hydrogenase that responds to ferrous ions (ferricyanide as acceptor) and is inhibited by phosphate.

The mechanism of H_2 activity in the symbiotic system has been obscure, for attempts to demonstrate a hydrogenase here have been unsuccessful. Recently, an enzyme preparation has been made from soybean nodules that reveals definite difference spectra between H_2-O_2, H_2-N_2, and H_2-vacuum. The results suggest that H_2 activated by such preparations reduces hematin compounds, and that N_2 specifically oxidizes a flavin component.

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From the lazy method of philosophizing in the closet, among books and diagrams, there never arose, there never will arise, any discovery of consequence: Great inventors usually understand the extent of their own principles too well, to leave much of the application of them to others.—THOMAS MELVILLE, "Observations on Light and Colours," *Essays and Observations, Physical and Literary* (Philosophical Society, Edinburgh, 1756), vol. II, pp. 12–90.