

ence. To succeed requires incessant vigilance to prevent undue encroachments on personal freedom and a patient determination that scientists and Government administrators cooperate and understand one another to make the system work.

References and Notes

1. *Science* **121**, 7A (11 Feb. 1955).
2. *Science* **121**, 490 (8 Apr. 1955).
3. A draft of this paper was sent to Oveta Culp Hobby, Secretary of the Department of Health, Education, and Welfare, on 23 Dec. 1954. The letter of acknowledgment stated that the problems discussed in the paper were being considered. On 27 Jan. 1955 I again wrote to Secretary Hobby asking whether the paper contained any misstatements about the U.S. Public Health Service. The reply mentioned none but stated that the problem was still under study. I then decided to submit the paper for publication, after revising the opening statement to take account of recent events and adding two paragraphs related to the use of anonymous informers—J. T. E.
4. *Science* **120**, 1010 (17 Dec. 1954).
5. Reprinted in *Science* **120**, 1009 (17 Dec. 1954).



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Localized Ultraviolet Irradiation of Parts of Chromosomes and of Cytoplasm in Dividing Cells

William Bloom, Raymond E. Zirkle, Robert B. Uretz, University of Chicago

Localized irradiation of small parts of chromosomes of mesothelial cells of newt (*Triturus viridescens*) with heterochromatic ultraviolet light produces a localized change of refractive index of the chromosomes, as is seen by phase-contrast microscopy in the living cells. The “pale” areas do not stain with ordinary nuclear stains or with the Feulgen method after fixation. Irradiation of equal amounts of cytoplasm during metaphase causes a collapse of the spindle and a subsequent “false anaphase” in which whole chromosomes aggregate in two clumps of random number. These clumps move apart and cytokinesis follows. Irradiation of cytoplasm during early prophase apparently inhibits development of the spindle but “false anaphase” nevertheless takes place.

We are testing the relative effectiveness of different wavelengths in producing these effects.

Progress in the Theory of Superconductivity

John Bardeen, University of Illinois

Considerable progress in understanding superconductivity has been made from both phenomenological and atomistic approaches, although difficulties remain. Magnetic properties can be accounted for by a model in which the ad hoc assumption is made that the electrons form a condensed superconducting state such that a finite energy $\epsilon \sim kT_c$ is required to excite an electron. Otherwise, excited electrons in the superconducting phase are assumed to be similar to those of the normal phase.

The theory does not lead to the London equations but to phenomenological equations similar to those suggested by Pippard. The current density at a point is determined by the field in a region of $\sim 10^{-4}$ cm surrounding the point. A dependence of penetration depth on mean free path, as observed by Pippard, is a consequence of the theory. It has not yet been possible to derive this model from first principles.

Recently, Pines and Bardeen have shown why, as is

indicated experimentally by the isotope effect, electron-lattice interactions are more important than Coulomb interactions in the normal-superconducting transition. This justifies the approach of Fröhlich and of Bardeen. The criterion for superconductivity is essentially that electron-lattice interactions be so large that they cannot be treated by perturbation theory. Satisfactory mathematical methods for treating such large interactions are lacking. It may be hoped that future developments will bridge the gap.

A Mono-acetyl Derivative of Chymotrypsin

Arnold Kent Balls, Purdue University

The question of the constitution of the active center of a hydrolytic enzyme has not yet received a satisfactory answer in any given case. One promising approach, however, appears to have been with chymotrypsin, whose inhibition by halogen phosphate esters results from the introduction of a single phosphoryl group into the enzyme molecule. For several reasons it seems likely that this group becomes attached to a part of the active center. The active center also appears to be clearly involved in the acetylation of chymotrypsin by *p*-nitrophenyl acetate, for the reaction occurs prior to a slow enzymatic decomposition of this substrate and consists in the transfer of one acetyl group to the enzyme molecule [Hartley and Kilby, *Biochem. J.* **56**, 288 (1954)].

While also studying this reaction, we have observed that it did not occur with chymotrypsinogen or with inactivated chymotrypsin. The acetylated protein was, moreover, inactive toward ordinary substrates. Chymotrypsin acetylated with ortho-, para-, or 2,4 dinitrophenyl acetate showed an unexpected stability in acid solution. By taking advantage of this property, it was possible to isolate the acetylated protein in apparently rather pure form. No rapid liberation of acid occurred when chymotrypsin reacted with a nitrophenyl acetate, but rapid liberation of acid did occur when a solution of the isolated protein was made slightly alkaline. The acetylated protein yielded one equivalent of a hydroxamic acid when treated with hydroxylamine at pH 6.5; thus the new substance appears to be unusually reactive. Reversion to chymotrypsin occurred rapidly in alkaline solutions. In a slightly acid

medium containing tyrosine ethyl ester (a substrate of chymotrypsin), practically no enzymic activity was found at first, but activity increased with time until eventually the entire activity of the original chymotrypsin had returned.

The resemblance between acetylated and phosphorylated chymotrypsin thus appears to be close, except for the great stability of the latter and the instability of the former.

Relativistic Formulation of Coulomb Scattering for Proton-Proton Collisions

Gregory Breit, Yale University

It is shown that the usual treatment of the collision process making use of Møller's formula (1) involves an inconsistency connected with the infinite cross section for small-angle scattering. A treatment of the collision process free of this objectionable feature has been devised. It is subject to the following limitations: (i) the expansion of the collision cross section in powers of v^2 , the square of the electronic charge, is limited to the first term and is therefore restricted in applicability to high energies; (ii) the effect of inelastic processes such as meson production is neglected, a restriction to energies below ~ 400 Mev; (iii) effects of the anomalous proton magnetic moment are considered approximately only.

The treatment makes use of (i) the possibility of introducing phase shifts relativistically in the center of mass system in an unambiguous manner, (ii) a general connection between phase shift and energy changes (2), (iii) the possibility of ascertaining the first-order changes in energy (3). The results form a relativistic extension of the Mott-Gordon solution for nonrelativistic Coulomb scattering. They contain some previously unsuspected types of spin-orbit and tensorlike forces and agree in some respects with some considerations of Garren (4).

The treatment presented here is suitable for the addition of phase shift caused by specifically nuclear effects to the Coulomb phase shifts. This research has been assisted by the Office of Ordnance Research.

References: (1) C. Møller, *Z. Physik* **70**, 786 (1931); (2) G. Breit, *Revs. Mod. Phys.* **23**, 238 (1951); (3) ———, *Phys. Rev.* **34**, 553 (1929); (4) A. Garren, *ibid.* **36**, 1709 (1954).

Quantum Efficiencies of Photosynthesis and Cell Growth in Thermophilic *Chlorella* at High Light Intensities

Dean Burk, Max Planck Institute for Cell Physiology, Berlin-Dahlem

George Hobby and Jehu Hunter, National Cancer Institute

Maximal quantum efficiencies were measured with rapidly photosynthesizing and multiplying thermophilic *Chlorella* strain 7-11-05 (Sorokin and Myers, University of Texas). A method was developed for simultaneous measurement of O_2 production and CO_2 consumption (thus $\gamma = x_{-CO_2}/x_{-O_2}$) in a single manometric vessel, involving complete fixation of large, prearranged amounts of CO_2 (that is, 1000 μ lit), confirmable as several-fold cell volume increases during a day's run and by wet combustion.

At 39°C and pH 4.5 \pm 1, with CO_2 /air mixtures and optimal mineral nutrition, and with incident light intensities up to 10 to 15 microeinsteins per minute per beam of 10-cm² area (about 1000 to 1500 ft-ca) of light of $\lambda < 650$ m μ , the observed quantum requirement for positive oxygen production, uncorrected for notable losses in

concurrent respiration and rapid growth, decreased from infinity at the compensation point to minimum values of 5 to 6 $h\nu/O_2$ at the upper part of the linear light-intensity response curves where the hourly volume of O_2 produced was 50 to 100 times the volume of cells, which were multiplying with a generation time as low as 4 hr, with maintenance of approximately constant chemical composition. Upon correction for energy expenditure losses necessarily involved in the measured, rapid growth (involving formation of numerous cell constituents, on the average more reduced than sugar, $\gamma = -0.95 \pm 0.05$) the estimated maximum quantum requirement for photosynthesis proper, in terms of N-free carbohydrate equivalent, approached the values of 3 to 4 $h\nu/O_2$ reported in recent years by Otto Warburg and coworkers for conventional nonthermophilic *Chlorella*, where rates of growth and photosynthesis are slower by nearly an order of magnitude. Clearly, the thermophilic *Chlorella* offer many advantages of theoretical and practical interest.

Relationship between Potassium Utilization and Nitrogen Balance

Paul R. Cannon, Laurence E. Frazier, Randolph H. Hughes, University of Chicago

Experiments were performed in normal and in protein-depleted rats in an effort to determine the metabolic interrelationships between positive and negative nitrogen balances and the capacity of the tissues to retain dietary potassium. When the animals were fed synthetic rations devoid of nitrogen and potassium, weight loss ensued, and nitrogen and potassium balances were negative. The administration of potassium chloride, while the rats were eating a nitrogen-free ration, failed to establish positive potassium balances or to engender weight gains, but the addition to the ration of a mixture of 16 amino acids caused the animals to go into both positive nitrogen and potassium balance. Following the elimination of one essential amino acid (tryptophan) from the ration, however, the animals went quickly into negative nitrogen and potassium balance. Finally, the feeding of the complete amino acid ration devoid of potassium led to the development of a positive nitrogen balance but a continued negative potassium balance.

These experiments emphasize the importance of anabolism in relation to the over-all utilization of dietary potassium. They suggest, also, that in the presence of a general catabolic state, tissue retention of dietary potassium is impaired and that, for optimal cellular utilization of potassium for purposes of tissue synthesis, the anabolic state is an essential requirement.

The Photosynthetic Cycle

Melvin Calvin, University of California, Berkeley

A cyclic sequence of transformation, including the carboxylation of RDP and its reformation, has been deduced as the route for the creation of reduced carbon compounds in photosynthetic organisms. With the demonstration of RDP as substrate for the carboxylation in a cell-free system, each of the reactions has been carried out independently *in vitro*. Further purification of this last enzyme system has confirmed the deduction that the carboxylation of RDP leads directly to the 2 molecules of PGA involving an internal dismutation and suggests the name *carboxydismutase* for the enzyme. As a consequence of this knowledge of each of the steps in the photosynthetic CO_2 -reduction cycle, it is possible to define the reagent

requirements to maintain it. The net requirement for the reduction of 1 molecule of CO_2 is 4 equivalents of H and 3 molecules of ATP. These must ultimately be supplied by the photochemical reaction. Some possible ways in which this might be accomplished are discussed.

The requirement of 4 equivalents of H and 3 molecules of ATP for the reduction of each molecule of CO_2 in the photosynthetic carbon-reduction cycle suggests the possibility that respiration may contribute some of the energy required for photosynthesis by supplying some of the ATP. This possibility was studied by measuring the quantum requirement of photosynthesis at various ratios of photosynthesis rate to respiration rate. Both corrected and uncorrected quantum requirements approach an experimental value of 7.4 with increasing photosynthetic rates, whereas the corrected rate approached 4 as the photosynthetic rate approaches zero. This may indicate a contribution of respiratory energy, probably as ATP, to photosynthesis.

We thus have the possibility of an interplay between the photosynthetic apparatus in the chloroplasts and the rest of the energy-converting apparatus of the cell outside at, at least, two points—namely, a number of intermediates in the carbon-reduction cycle which are common to both, as well as generalized energy storage chemicals such as ATP, which are generated and used by both. Although we can recognize a few of the conditions that will control the relative contributions to cellular behavior of these two processes, it remains for the future to establish precisely the externally controllable variables that can influence not only both processes but their interplay as well.

This work was sponsored by the U.S. Atomic Energy Commission.

Spectroscopic Effects Coincident with the Onset of Oxidative Phosphorylation in Mitochondria

Britton Chance and G. R. Williams,
University of Pennsylvania

The respiratory chain is believed to consist of a series of 1- or 2-electron oxidation-reduction processes, of which the reaction of the ferrous and ferric forms of two cytochromes, $a''' + c'' \rightarrow a'' + c'''$, is an example. This chain catalyzes electron transport from reduced pyridine nucleotide (DPNH) to oxygen, the latter being reduced to water. A portion ($\sim 10,000$ cal) of the free-energy change of this reaction is conserved and, through one or more transformation reactions, affords the energy necessary to convert adenosine diphosphate (ADP) to adenosine triphosphate, the latter providing a ready source of energy for cell function. This process of oxidative phosphorylation is best studied in mitochondria prepared from liver by homogenization and differential centrifugation (Schneider). An interesting property of carefully prepared mitochondrial suspensions is that their electron transport becomes severely inhibited (more than 90 percent) when added ADP is exhausted, and the transformation reactions can proceed only slowly (Lardy).

Our spectroscopic observations of the turbid mitochondrial suspension show that this inhibition reaction is accompanied by changes in the steady-state levels of six members of the respiratory sequence—the components near oxygen becoming more oxidized and those near substrate becoming more reduced. Between cytochromes c and a there is a "crossover" point in the sign of these changes as if an inhibitor reacted with a''' or c'' . Evidence in favor of the idea that the reduced component is com-

bined with the inhibitor, I , to form, for example, a high-energy compound, $c'' \sim I$, is afforded (i) by the fact that the inhibited respiratory chain is found to contain considerable amounts of reduced forms of cytochromes c and b , flavoprotein, and especially DPN, and (ii) by kinetic studies that show very little activity of the inhibited system in DPNH oxidation but show considerable activity in flavoprotein reduction. Thus cytochrome c is identified as a site of oxidative phosphorylation. Addition of various azide concentrations shifts the "crossover" point along the respiratory chain so that cytochrome b and DPNH can also be shown to be similarly involved in phosphorylation. More recent evidence in favor of this mechanism is afforded by the reaction of amounts of ADP with the azide-inhibited respiratory chain roughly equivalent to the measured content of DPNH. Such a reaction is understandable if the DPNH is bound as $\text{DPNH} \sim I$. This reaction would also explain the small dinitrophenol-sensitive phosphorylation observed by Lehninger in cyanide-inhibited systems.

Comparative Considerations Concerning the Dirichlet Principle and the Douglas Principle

Jesse Douglas, Columbia University

The title and contents of a recently published book, *Dirichlet's Principle*, as well as the general tendency of some recent mathematical writings, have seemed to promote among nonconnoisseurs the impression that one can solve the Plateau problem with this classic principle. All such attempts, however, extending over an 80-year period in mathematical history (1850–1930), met with failure. The fact is, of course, that the Plateau problem presents a new difficulty of essentially higher order than the fundamental problems in complex variable and conformal mapping whose solution, following the lead of Riemann, has been based on the Dirichlet principle.

The Plateau difficulty could be resolved only by an entirely fresh approach. I developed such a new method during the years 1926–29 and described it in a series of abstracts [*Bull. Am. Math. Soc.* (1927–30)]. A fully detailed paper appeared in [*Trans. Am. Math. Soc.*] 1931. The Douglas principle consists in the minimizing of the functional $A(g) = \text{mean square of the ratio of corresponding chords of the given contour } \Gamma \text{ and the unit circumference } C \text{ (times } \pi \text{)}$. The argument g is an arbitrary, unspecified, one-one continuous map of C onto Γ , and corresponding chords are those whose end-points are correlated by g .

In the main form of Dirichlet's principle, on the other hand, the argument ϕ in the basic functional $D(\phi)$ is a numerical-valued function with a prescribed value $f(p)$ at each point p of the boundary Γ of a given plane region.

These comments are elaborated along the general lines of my previous paper, "Remarks on Riemann's doctoral dissertation," [*Proc. Natl. Acad. Sci. U.S.A.* 24, 297 (1938)].

Concentration of Lattice Defects in Crystals Produced by Reactor Irradiation

G. J. Dienes, Brookhaven National Laboratory

A relatively high concentration of lattice defects can be produced in crystals by high-energy particle bombardment. Radiation effects are of great interest as new tools for probing the intricate connections between measurable crystal properties and crystalline imperfections. An outstanding problem in this field is the absolute measurement

of the number of imperfections introduced into the crystal.

Recent work (with J. J. Antal and R. J. Weiss) indicates that neutrons of sufficiently long wavelength (6 to 12-Å range) are scattered isotropically by isolated point defects and that this scattering can be measured when crystalline effects (Bragg scattering) are absent (Babinet's principle). The cross section for this nuclear type of scattering is accurately known from other measurements. The attenuation of a long wavelength neutron beam during its passage through the material can be measured in transmission. Experiments are presented which indicate that the number of defects can be measured by this technique in an absolute way with good accuracy.

Another attractive method is to study the number and nature of displaced atoms by means of changes in optical properties. For this purpose one must separate the effects resulting from displaced atoms from those produced by ionizing radiation. This has been accomplished recently (with Paul W. Levy) using α - Al_2O_3 . Absorption bands specific to reactor irradiation have been found. Some properties of these bands are presented. Potentially this is also an absolute and very sensitive method for determining defect concentration. Combination of these two techniques should cover a wide range of imperfection concentrations.

This work was performed under contract with the U.S. Atomic Energy Commission.

Toxicity of Serum from Irradiated Animals

Abraham Edelmann, *Brookhaven National Laboratory*

The existence of a substance elaborated as a result of irradiation and carried by the blood has long been postulated. Much indirect evidence for its existence has been found but no direct evidence.

In the present experiments, serum taken from rats that were given 1000 r of whole-body x-irradiation 24 hr prior to collection of the blood causes death in unirradiated adrenalectomized rats. Serum from unirradiated rats does not have this effect. In similar tests 0.2, 0.4, 0.6 ml of serum from irradiated rats is toxic to adrenalectomized mice, the time being dose-dependent. The effects of the toxin are additive with those of whole-body x-irradiation, as is indicated by the fact that there is a much higher mortality in mice receiving x-irradiation plus serum from irradiated rats than for mice receiving the same dose of radiation plus control serum. Hematological effects qualitatively similar to those seen after irradiation occur after serum injection. The toxic effect disappears upon standing 30 min at 25°C and is retained overnight at 0°C. Ten hours after irradiation is the earliest time it is detectable and its concentration appears to increase after this time.

Research carried out at Brookhaven National Laboratory under the auspices of the U.S. Atomic Energy Commission.

Etiology of Gastric and Duodenal Ulcers

Lester R. Dragstedt, *University of Chicago*

The concept is proposed that ulcers are due to a hypersecretion of gastric juice rather than to a local decrease in the resistance of the mucous membrane to digestion and, further, that the hypersecretion of gastric juice in duodenal ulcer patients is usually of nervous origin, whereas the hypersecretion of gastric juice in gastric ulcer patients is usually of hormonal origin and is caused by hyperfunction of the gastric antrum. Patients with duodenal ulcers secrete from 3 to 20 times as much gastric juice in the empty stomach at night as do normal indi-

viduals. A hypersecretion of this degree, if reproduced in experimental animals, invariably leads to the production of duodenal ulcers. This hypersecretion is abolished if the vagus nerves to the stomach are divided; and, roughly paralleling the fall in the secretion of gastric juice, the pain of ulcer disappears and the lesions heal and remain healed.

The antrum of the stomach is the sole source of the gastric secretory hormone, the gastrin of Edkins. Factors that stimulate the antrum to release gastrin have been found to be prolonged contact of the antrum mucosa with food and tension within the antrum aroused by peristalsis. In patients, antrum hyperfunction usually results from stenosis at the pylorus or stasis in the stomach as a result of impaired motility. Both factors are frequently present in patients with gastric ulcer.

Helium II in Rotational Flow

R. P. Feynman, *California Institute of Technology*

It will be argued that in liquid He II flowing at absolute zero the circulation on any path must be quantized at an integral multiple of a unit $2\pi\hbar m^{-1}$ (m is the atomic mass of He⁴). If the velocity is continuous in a simply connected region, this requires $\nabla \times \mathbf{V} = 0$. In general the velocity will not be continuous, however; the vorticity will be zero everywhere except on certain line singularities (near which the velocity varies inversely as the distance to the line). These quantized vortex lines, suggested also by L. Onsager [*Nuovo Cimento*, 6, supp. 2, 249 (1949)], will appear whenever rotational flow is demanded. Thus in a rotating cylinder, rotating at angular velocity ω , $2\omega m/\hbar$ lines will form per square centimeter parallel to the axis (hence, the average vorticity is 2ω , as required). Energy is required to form these lines. The flow through a thin tube will be irrotational and frictionless as long as kinetic energy sufficient to form vortex lines is not available. The critical velocity, estimated in a rough manner from this, is of the same order as the experimental values. At much higher velocities so many lines can be formed that the quantization is not important and the resistance should approach that for turbulent fluids. It is proposed that rotons are the smallest ring vortices that such lines can form. The degradation of turbulent motion at absolute zero to heat is discussed qualitatively in this view.

Depression of Estrone-Induced Uterine Growth by Steroids

Charles Huggins and E. V. Jensen, *University of Chicago*

The exuberant uterine growth, which is induced in hypophysectomized albino rats by the injection of estrone, can be inhibited to the extent of 30 to 40 percent by the simultaneous administration of certain other steroids. In the estrane series, such inhibitory steroids include estriol (in confirmation of the results of Hisaw et al.), 16-*epi*-estriol, estradiol-3,16 α , estradiol-3,16 β , and 6-ketoestradiol-3,17 β . In the androstane series, depression of estrogen-induced uterine growth was observed with dehydro-*epi*androsterone, 4-androstene-3,17-dione, and 4-androsten-3-one but not with testosterone. In the pregnane series, effective inhibitors include progesterone (in confirmation of Courrier), 5-pregnen-3 β -ol-20-one, 11 β -hydroxyprogesterone, desoxycorticosterone and cortisone, whereas the 17-*isopregnane* derivative, ethinyltestosterone was likewise effective.

On the basis of the present results, it appears that

introduction of a hydroxyl group at C₁₆ or a ketone group at C₆ imparts inhibitory properties to the phenolic estrogen molecule, whereas the Δ^4 -3-ketone grouping and the presence at C₁₇ of a carbonyl group or a two-carbon side chain are molecular features that contribute to the inhibitory ability of compounds of the androstane and pregnane series.

Mathematical Analysis of Atmospheric Pollution in an Urban Area

François N. Frenkiel, *Applied Physics Laboratory, Johns Hopkins University*

Mathematical models of atmospheric pollution can be used to study the probable pollution patterns in an urban area. One of the simplest models can be constructed by including in the description of the model (i) the distribution of pollution sources and their emission conditions, (ii) the micrometeorological characteristics that directly affect the dispersion of pollutants, and (iii) the orographic conditions of the area. The sources of pollution may include point sources and area sources that have intermittent or continuous emissions. The description of the micrometeorological conditions depends on the scale at which the pollution is to be studied. The wind velocities are separated in "mean" wind velocities corresponding to this scale and in turbulent fluctuations. A thermal inversion is represented by proper boundary conditions. The statistical theory of turbulent diffusion can then be applied to determine the mean concentration distribution of pollutants due to each pollution source. Under simplified assumptions, one can then determine the mean concentration pattern of pollution over the urban area as a function of the time. The relative contributions of each of the pollution sources to the local contamination at various points of the area can then be determined.

As an application of this method of study of atmospheric pollution, the case of Los Angeles County has been considered. In particular, the probable mean concentrations from point sources representing certain polluting industries are compared with those representing the pollution from automobiles distributed over the county. The relative contribution of the various sources are then determined as a function of the hour of the day and compared with some experimental measurements. The use of high-speed computing methods in this analysis has been examined.

This work was supported by the Bureau of Ordnance, Department of the Navy, under contract NOrd 7386.

Central Versus Sensory Control of Food Intake in Genetically Obese Mice

John L. Fuller and George A. Jacoby, Jr.,
R. B. Jackson Memorial Laboratory

Recessive hereditary obesity in mice was reported in 1950 by Ingalls, Dickie, and Snell. The syndrome resembles hypothalamic obesity in the rat, but this part of the brain has been described as structurally normal. Since hyperphagia in rats with hypothalamic lesions has been shown to depend upon sensory control of appetite rather than a stronger hunger drive, it was considered pertinent to learn whether this is true in obese mice.

Two treatments were employed: (i) dilution of the ordinary ration by cellulose, and (ii) adding bitter substances to the regular diet. Dilution reduced nutritive intake in obese animals more than in control nonobese

sibs. Both groups ate less when the change was first made, but controls increased their intake to normal levels as their weight fell. Adjustment of intake to cope with weight loss in obese subjects was very limited. Controls adjusted to dilutions of 35 percent, and fairly well to 50 percent. Obese mice did not completely adjust to 25-percent dilution and were severely affected by 35-percent dilution. Similar differences in adjustment were found with bitter additives in the diet.

In normal well-nourished mice, food intake is under sensory control, but central mechanisms sensitive to energy needs take over when homeostasis is threatened. The central mechanisms are insensitive in obese mice. Since the effects on motivation are similar in the genetic and surgically induced syndromes, it is suggested that the genetic lesion affects hypothalamic centers.

Biochemistry as Influenced by Syntheses in the Carbohydrate Field

Hermann O. L. Fischer and C. E. Ballou,
University of California, Berkeley

In our laboratory, a number of phosphorylated intermediates of glycolysis and fermentation have been synthesized. This paper discusses how these chemically pure substrates were instrumental in the development of the Embden-Meyerhof scheme of glycolysis. Recently, C. E. Ballou succeeded in carrying out the synthesis of D-glyceraldehyde-3-phosphoric acid. The older synthesis of E. Baer and H. O. L. Fischer provided only the corresponding racemate. The chemical synthesis and the usefulness of this new substrate for the elucidation of metabolic pathways is discussed.

Electrification of Cloud and Rain Drops by Ionic Diffusion and Droplet Association

Ross Gunn, *U.S. Weather Bureau*

It is found that the observed electrification of cloud droplets and rain is primarily a manifestation of the free ions produced in the atmosphere by cosmic rays and radioactivity. Such ions diffuse onto cloud droplets as a result of their thermal motions and electrify them. The electrification is systematic when the ionic conductivities of the positive and negative ions are different, but a large random electrification still persists even when the conductivities are the same. Inside of stable clouds, random electrification plays the major role and an equipartition is established between a droplet's electrostatic energy and its mean thermal energy. In such clouds diffusion processes transfer to each droplet of radius 2.5×10^{-4} cm, an average of eight elementary charges. About 47 percent of the droplets carry positive charges and another 47 percent carry negative charges. Sometimes systematic electrification of a selected sign is superimposed. A detailed estimate of the charge distribution among the droplets is found to agree with that measured on laboratory produced clouds.

When a cloud finally becomes unstable the electrified cloud droplets collide and associate to form drops that grow in size and accumulate charge. The electromechanics and statistics of the association process show that about half of the growing raindrops accumulate high positive charges, whereas the other half accumulate negative charges. An approximate equipartition is established between the electrostatic energy of the large drops and the relative kinetic energy of the smaller droplets. Esti-

mates of the magnitude and distribution of the raindrop charges are found to agree with those directly measured inside precipitating regions. Although the electrification is fully developed, even in warm clouds, the estimated charges are as large as those usually measured in thunderstorms—namely, 100 electrostatic units per gram of precipitation. The study leads directly to quantitative descriptions of a number of heretofore puzzling facts of precipitation electricity.

Studies on Protection by Treatment before and after Exposure to X- and Gamma-Radiation

Alexander Hollaender, *Oak Ridge National Laboratory*

The protection of living cells against ionizing radiation by chemical means has developed rather rapidly during the last few years. In our experiments, β -mercaptoethylamine is outstanding. Recovery in mice is favored by treatment after exposure with nonirradiated spleen (Jacobson); bone marrow (Lorenz and Congdon); and in bacteria by glutamate, guanine, and uracil. Most of the protective ability of β -mercaptoethylamine for broth-grown *Escherichia coli* is intrinsically dependent on the supply of recovery factors given afterward. The mutation rate for *E. coli* reversions is not in itself directly proportional to the amount of radiation absorbed but rather inversely to the number of organisms surviving irradiation. The mutation effect apparently is not immediate, but, rather, is a delayed effect.

In an effort to apply these findings to mammals, the mice were given S,β -aminoethylisothiuronium $\cdot Br \cdot HBr$, which appears to give better protection than β -mercaptoethylamine, is less toxic, has a wider range of protective concentration, and is considerably more stable. Bone marrow and daily injections of streptomycin were given after irradiation. Highly significant survival has been obtained in mice treated with aminoethylisothiuronium before exposure to 2400 r and injected with bone marrow suspension and streptomycin after irradiation. This is for hybrid mice, which, without protection, show a significant survival after doses of cobalt gamma-radiation somewhat higher than 800 r. It appears that the chemical treatment before exposure and treatment with bone marrow afterward are additive. It is too early to tell what the effect will be on fertility, genetic changes, leukemia, cataract induction, and so forth. These results show that it is possible to extend the survival of mammals by proper treatment in excess of the usual accepted lethal dose.

The work on bacteria was done in cooperation with G. E. Stapleton, A. J. Sbarra, D. Billen, and C. O. Doudney. The work on mice was done in cooperation with W. T. Burnett, Jr., and D. G. Doherty.

Intensities of 30,000 Spectral Lines

William F. Meggers, Charles H. Corliss, Bourdon F. Scribner, *National Bureau of Standards*

Excepting a few hundred atomic spectral lines for which physical intensities have been measured, the intensities of spectral lines are generally given by numbers that have no meaning in comparing lines in different spectral regions or in spectra of different elements. An attempt is being made to assign detectability numbers to spectral lines actually observed when 70 chemical elements are equally diluted and excited in a copper arc. From these numbers physical intensities on a uniform scale are being determined for about 30,000 lines of 70

elements excited in a d-c arc between electrodes of pressed pure copper powder to which 0.1 atomic percent of an element was added. One atom of an added element then radiates in competition with 1000 copper atoms and emits a simplified spectrum of its stronger lines.

The spectra from 2000 to 9000 Å were photographed with a stigmatic concave grating spectrograph while a stepped sector was rotating in front of the slit. Apparent intensities of all added element lines observed were first determined relative to internal standards in the copper spectrum and then converted to true intensities by comparing the copper spectrum with that of an incandescent ribbon filament lamp operated at a known temperature.

That these intensity numbers really represent true relative energies was proved by comparing them with accurately measured relative intensities of lines in multiplets and with relative *gf* values of lines measured by R. B. and A. S. King [*Astrophys. J.* 82, 377 (1935); *ibid.* 87, 24 (1938); *ibid.* 105, 376 (1947)] in furnace absorption spectra of several elements. The latter comparisons indicate that the temperature of a 220-v, 10-amp, copper arc is $4940 \pm 290^\circ K$. This fact permits the conversion of our intensity numbers to transition probabilities or line strengths or relative *gf* values which may be of value to astrophysicists and to theoretical physicists.

Phenomenon of Sudden Death in Man and Animals

Curt P. Richter, *Johns Hopkins Medical School*

Cannon reported on sudden death in man under voodoo influence. Rats apparently die a similar death under restraint or in situations in which they are helpless.

Theory of the Auroral Zone

Donald H. Menzel, James W. Warwick, Robert S. Lawrence, *Harvard College Observatory*

Sidney Chapman suggested many years ago that clouds of highly ionized gas, ejected from disturbed regions of the sun, cause many terrestrial magnetic storms. During the initial phase of a magnetic storm, the ion cloud, moving earthward, pushes and compresses the earth's magnetic field into the space between the cloud and the earth. During this compression, the magnetic field exerts a reaction force against the surface of the cloud.

Calculating on the basis of a plane cloud, Chapman recognized that the magnetic pressure vanishes at two points, where the cloud can penetrate into the earth's field. Tracing the course of such a horn of gas, as it moves along a line of magnetic force down to the auroral zone at the surface of the earth, we find that it converges to a point some 27 deg from the geomagnetic pole.

This simple theory of the auroral zone predicts that auroras would occur on the sunlit hemisphere at just two locations—in direct contradiction to the observed occurrence of auroras at night, along the entire auroral zone. However, the simple theory neglects important effects resulting from the formation of a hollow in the surface of the ion-cloud. We show that the hollow in fact allows horns to spread in longitude completely around the auroral zone. The broad sheet of auroral matter follows a path practically identical with that of the simple theory.

Precise Measurement of Infrared Spectra

Earle K. Plyler, *National Bureau of Standards*

During the last 2 years a method of measurement has been in operation at the National Bureau of Standards which makes it possible to determine the wavelengths of infrared atomic spectra and of the absorption lines of molecular spectra with an error of 1 part in 500,000. In the region of 5μ spectra are measured to a precision of 0.1 Å. The method consists of using the interference pattern from a Fabry-Perot interferometer as a comparison spectrum. The interference maxima are translated to wave numbers by superimposing standard atomic lines on the recorded fringe system.

Application to measurement of wave lengths of the infrared atomic spectra of Hg, Kr, and Xe is given. The fundamental band of carbon monoxide has also previously been measured by this method and the results obtained for this molecule are discussed. After other bands have been measured, there will be available a set of standard wave lengths for the infrared region.

Energy and Angular Distribution of Singly Scattered Electrons

L. Marton, J. A. Simpson, T. McCraw,
National Bureau of Standards

The energy and angular distribution of medium-energy electrons scattered by solids have been measured with an energy resolution of better than 1 part in 1500 and an angular resolution better than 10^{-3} rad. The instrument, which is automatic, uses thin foils (100 to 400 Å) as targets.

To date the materials studied have been metals and particularly gold. The typical energy spectrum consists of an elastic peak and one or more characteristic inelastic peaks on a continuous background. The relative cross sections of these peaks vary strongly with angle. A typical angular distribution at fixed energy consists of a very rapid fall off of intensity, ending at about 20 min of arc followed by a long flat portion extending out to the first diffraction maximum at about 2 deg. The exact shape is a function of material, thickness, and degree of crystalline orientation.

The relationship of these scattering patterns to the current theories is briefly discussed.

Experimental Origin of a Reproductively Isolated Population in the Grass Genus *Elymus*

G. Ledyard Stebbins, *University of California, Davis*

The grass species *Elymus glaucus* is known to consist of a large number of entities which are highly fertile within themselves, but which form sterile hybrids when crossed with each other. Some of these genetic microspecies can be defined on morphologic grounds, while others cannot. Many of them vary in the direction of other species with which *E. glaucus* frequently forms natural hybrids, particularly *Sitanion jubatum* and *S. hystrix*. This has led to the hypothesis that they originated by backcrossing from these highly sterile natural hybrids. To test this hypothesis, clonal divisions of an artificial F_1 hybrid between *E. glaucus* and *S. jubatum* were interplanted with divisions of the *E. glaucus* parent.

From 150,000 florets harvested from the hybrid, four plants of the first backcross progeny were obtained. Three

of these were sterile; one had 10 percent of seed setting. Progeny of this plant from two generations of self-fertilization were highly fertile, only moderately variable, and agreed with *E. glaucus* in external morphology and chromosome number, except that they possessed a few characteristics suggesting *Sitanion*. When these plants were crossed with the *E. glaucus* parent of the original hybrid, the F_1 progeny of this cross were highly sterile. This origin of a genetic microspecies without change in the chromosome number is explained on the basis of segregation of small differences in chromosome structure which were the basis of the sterility of the F_1 *E. glaucus* \times *S. jubatum* hybrid.

Cosmic Rays Outside of the Earth's Atmosphere

James A. Van Allen, *State University of Iowa*

Cosmic radiation has been studied outside of the appreciable atmosphere of the earth over a range of geomagnetic latitudes from the equator to the North Pole. These studies have been made by means of equipment borne by high-altitude rockets. With the help of the theory of the motion of charged particles in the earth's magnetic field, there has resulted a considerably expanded and improved knowledge of the following matters: the cosmic-ray intensity in the astronomical vicinity of the earth, the momentum spectrum of the primary radiation, the cosmic-ray albedo of the atmosphere, the absence of low-momentum primaries, and the cosmic-ray energy balance in the atmosphere. Measuring techniques and detailed results are sketched and interpretation in terms of the aforementioned aspects of the subject are given.

Heat Balance of the Earth, the Moon, and Mars

Harold C. Urey, *University of Chicago*

Recently published abundances of potassium, uranium, and thorium in meteorites are so high that much greater heat would be generated in the earth than is being lost if these abundances are characteristic of the earth. It is suggested that these elements have been concentrated in the meteorites by a factor of 3.2 or perhaps more. In this way it is possible to secure agreement in the heat balance of the earth.

If these smaller amounts of these elements represent the solar and planetary abundances, it is possible to account for the high rigidity of the moon and the characteristics of Mars. Melting such as is observed in the meteorites, if it was produced by radioactive heating by K, U, and Th, as suggested by Kuiper (at the AAAS meeting, Boston, December 1953), would require very long periods of time. It seems likely that this melting was due to short-lived nuclides produced only shortly before the formation of the sun, or to other sources of heat.

Induction of Additional Hybrid Sterility in *S. cereale* \times *montanum* by Irradiation of Pollen

Samuel Price, *U.S. Department of Agriculture*

The interspecific F_1 hybrids, *Secale cereale* L. \times *montanum* Guss. exhibit great variability in pollen fertility and seed set. Meiotic irregularities and this partial sterility were studied in "control hybrids" and in "r-hybrids." The latter were obtained by x-irradiation (about 1250 r) of the pollen used in the hybridization.

Control hybrids are heterozygous for two reciprocal translocations which are responsible for a maximum association of $4_{II}+1_{VI}$. Inversion bridges occur but in no greater frequencies than within parental species.

Of 26 r-hybrids that were examined cytologically, 17 contain additional induced translocations. Inversions have been induced in several plants. One r-hybrid exhibits fragmentation in meiosis. Another contains a small centric ring fragment.

In control hybrids, pollen fertility and seed set vary independently, and neither is correlated with detectable chromosome irregularities. A large portion of the variation that obscures the effects of chromosome aberrations is thought to be genic. Genes that effect fertility within the parental species might well be the basis of this variable, interspecific, partial sterility.

In r-hybrids, pollen fertility and seed set are weakly correlated, but neither is correlated with observable chromosome irregularities. A cytologically undetectable addition to genetic variation has been induced which influences pollen fertility and seed set similarly. Induced "point" mutations are not entirely discounted, but the addition to sterility is more likely based in cryptic structural changes in the chromosomes.

Diurnal Variation of Irregular Geomagnetic Fluctuations

Seth B. Nicholson, Mount Wilson and Palomar Observatories

Oliver R. Wulf, U.S. Weather Bureau, California Institute of Technology

We have studied the diurnal variation of irregular geomagnetic fluctuations in moderately low latitudes using the eight daily K numbers (3-hr-range indices) for the seven years 1940-46 and for the six observatories Alibag, Watheroo, Honolulu, Tucson, San Juan, and San Fernando. These observatories were chosen because they are fairly uniformly distributed in longitude, being at 73°E, 116°E, 202°E, 249°E, 294°E, and 354°E, respectively.

A local time variation, to be expected from the work of earlier investigators, is apparent also in these data. The present data indicate a minimum near sunrise and a maximum in the late evening. This diurnal variation appears to have a small seasonal change.

When the local time variation is deducted from the original data for each observatory, the remainders suggest a universal time variation that exhibits a pronounced seasonal change.

Remarkably Preserved Miocene Arthropods from the Mojave Desert

Allison R. Palmer, U.S. Geological Survey

Insects, arachnids, and crustaceans, in a state of near perfect preservation, have been recovered from limestone nodules in lacustrine sediments of Miocene age from the Calico Mountains in the Mojave Desert, California. Specimens representing 25 species are partly or completely replaced by silica, celestite, calcite, analcite, or an undetermined organic compound. External details are exquisite in many instances, and remarkable examples of internal anatomical features are preserved in three insect species. This is the first record for most of these features in fossils.

Remnants of the tracheal systems can be observed in

dytiscid beetle larvae, adult midges, and dragonfly larvae. Spermathecae were found in several female midges and internal genital structures in a male. One midge pupa contains a perfectly preserved adult female, which was ready to hatch. Part of the thoracic tracheal system and the spermathecae are visible within this female. Color patterns are present on both male and female midges. A dragonfly larva shows the rectal gill system, the heart, part of the alimentary canal, Malpighian tubules, and muscles.

Absence of Amino Acid Incorporation into Antibody during the Induction Period

W. H. Taliaferro and D. W. Talmage, University of Chicago

Donor rabbits were given two injections of bovine serum albumin a month apart. Three days after the second injection, at about the end of the induction period when there was some coprecipitating but no precipitating antibody in the serum, the spleen was removed, minced, and injected into normal recipient rabbits. The recipients showed an early rise of serum-precipitating antibody owing to the transferred splenic cells. Donors or recipients were administered various amounts of yeast hydrolyzate containing amino acids labeled with S^{35} . Administration of S^{35} to seven donors resulted in only a low-grade radioactivity of precipitin in the recipient. Labeled antibody was calculated to be 0.3 to 4 percent of the antibody in the recipient and could be partly accounted for by the passive transfer of labeled coprecipitating antibody from the donor. In contrast, administration of S^{35} to three recipients resulted in a marked radioactivity of precipitin in the recipient which showed specific activities of 1.3 to 2.5 times that of the serum protein.

Control experiments indicated that S^{35} was stably bound to passively transferred antibody. The results indicate that almost all of the sulfur-containing amino acids present in the antibody are drawn from the amino acid pool during the rise of serum antibody and not during the induction period. They further suggest that the induction period is concerned with the production of antibody-synthesizing enzymes rather than of amino acid-containing antibody precursors.

Differentiation of Xylem in Plants

Ralph H. Wetmore, Harvard University

In the culturing of parts of plants *in vitro*, it was found that if an apex of lilac, with two or three pairs of leaf primordia, was grafted into a piece of lilac callus, the apex grew into a plant. Moreover, in the characteristically homogeneous parenchyma of the callus host, vascular tissue developed across the graft bridge. The technique of successful grafting of apices, as Camus (1949) has pointed out, depends upon filling the incision into which the scion is placed with agar, or some similar substance, which prevents the cut cellulose walls from drying out.

Experimental evidence indicates that if the incision is filled with plain agar, response to grafting occurs on the flanks of the scion. Several to many centers of mitotic activity develop, each giving rise to a strand of differentiated xylem cells in the callus.

If instead of agar, agar containing an auxin in physiological concentrations is used in the incision, the vascular strands are found in the callus as before, but the distances from the scion are greater with higher concentra-

tions of auxin. If, instead of a grafted scion, agar containing an auxin in physiological concentration and no scion be used in the incision, vascular strands of xylem are formed in the callus as before. Thus far, no phloem has been recognized in the experiments.

The results appear to be in accord with Jacobs' findings: the production of xylem occurs when sugar and auxin are available to the callus. The corollary seems to be in the genesis of strands of xylem in the callus wherever limitations of sugar or auxin concentration are satisfied. It may well prove to be true that the vascular cylinder in a stem forms where it does because the demands for xylem formation are better satisfied in the elongate cells of the procambium than in the shorter, more or less isodiametric cells of the neighboring cortex and pith.

Fruity Mutant of the Slime Mold *D. discoideum*: Alterations in the Normal Pattern of Cellular Differentiation

Maurice Sussman, *Northwestern University*

In *Dictyostelium discoideum* wild type, cessation of growth is attended by the appearance of initiator cells within the population of myxamoebae. Each initiator evokes the formation of a multicellular aggregate by its neighbors. The aggregate is subsequently transformed into an organized fruit with spores, stalk, and basal disk cells. Under the conditions employed for analysis, the ratio of initiator cells to responder cells (the remainder of the population) is 1:2200. The genetic alteration in the fruity strain leads to an enormous increase in the number of initiators such that the ratio of initiators to responders is 1:24. The examination of aggregations by mixed populations of mutant and wild type has indicated that the mutant initiators can provide stimuli affecting any responder cell whether mutant or wild type.

The multitude of initiators in the mutant stock results in the formation of aggregates containing very few cells and correspondingly tiny fruits. Some of the latter have been found to consist of as few as 12 cells and yet to retain the normal structural relationships in terms of gross proportions and cellular morphology. The pertinence of these results to the problem of regulation in morphogenetic systems is discussed.

Differential Growth of Mental Abilities

L. L. Thurstone, *University of North Carolina*

The components of human intelligence that have been isolated during the last two decades by the methods of multiple-factor analysis are called primary mental abilities. Data have been collected for a large school population for the age span 5-19. This paper reports the mental growth curves for seven of the primary mental abilities. These are perceptual speed P, number N, the first space factor S₁, verbal comprehension V, word fluency W₁, immediate memory M₁, and reasoning R.

In order to determine the shapes of the mental growth curves, it was necessary to establish a metric. This is a scaling problem that was solved some years ago. A rational origin for the scale was determined as the point on the scale at which variability at point age vanishes since the variability cannot be negative.

All the mental growth curves so far determined are S-shaped with inflection points at an early age of 3 to 7. All of them approach maturity asymptotically.

The primary mental abilities mature at different ages. The perceptual speed factor P matures to $\frac{4}{5}$ of the adult level at about age 10. The two verbal factors mature to the same level at about age 14.

It seems likely that in the future teaching methods will be adjusted to the imagery type of each child. A child's mental profile can be determined at age 5.



News and Notes

Scientific Abstracting in the U.S.S.R.

The following article, written by D. Panov, director of the Institute of Scientific Information of the Academy of Sciences of the U.S.S.R., appeared in a recent issue of Pravda. In translation its title appears to be "Study achievements of science and technics more profoundly."

Well-organized information, on the achievements of science within our country and outside it, is called upon to play an important role in the struggle for the further advance of science.

About 2 years ago there was set up in the Academy of Sciences of the U.S.S.R. an Institute of Scientific Information, which pursues the aim of keeping Soviet scientists and industrial and agricultural workers permanently acquainted with the achievements of science and technics throughout the world.

In order to give Soviet readers the chance of acquainting themselves with the colossal amount of new material that is continually appearing in thou-

sands of journals published in all the languages of the world (in the sphere of chemistry alone there are published yearly about 70,000 new articles, books, and patents), great preparational work is necessary.

The Institute of Scientific Information of the Academy of Sciences of the U.S.S.R. publishes regularly so-called "journals of abstracts" on mathematics, mechanics, astronomy and geodesy, physics, chemistry, and biology, which are, as it were, a key to world literature in the respective branches of science.

A tremendous number of journals, scientific works, books, and other literature are examined regularly in order to obtain the necessary material. In 1954, 6892 foreign and 998 Soviet periodicals were subjected to this examination.

The journals of abstracts enable readers to acquaint themselves in Russian with material published in scientific and technical journals that come out even in the most distant parts of the globe and in the most difficult languages. The summaries, besides a bibliographical description, contain a complete outline of