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Magnetic Fields of the Sun

Harold D. Babcock and Horace W. Babcock
Mount Wilson and Palomar Observatories

Magnetograms of weak fields on the surface of the sun are being obtained daily. The campaign on this problem, initiated in 1912 by George E. Hale, has resulted in the development and application of superior diffraction gratings yielding a resolving power of 600,000 and a dispersion of 11 mm/A, as well as a photoelectric detector for minute Zeeman effects that is free of systematic error. These, in combination with an alternating electro-optic analyzer and a scanning system, permit conformal magnetic mapping of the sun's disk in a pattern of 19 or more parallel traces with a sensitivity of 1 gauss. Daily records cover 8 months, and observations are planned for the complete solar cycle.

A variety of bipolar or complex multipolar fields of intensity from 2 to 30 gauss and having a fine structure is usually found in heliographic latitudes up to $+40°$, even in the absence of visible sunspots. The intensity and extent of the solar magnetic fields vary from day to day. The fields precede and follow the appearance of visible spots. Occasional weak but extensive unipolar magnetic areas are observed in low latitudes. Special attention has been given to high latitudes above $\pm 60°$ where there is evidence of a weak but persistent dipolar field opposite to that of the earth. The mean polar intensity is currently of the order of 5 gauss, and the dipole moment is estimated to be approximately $+2 \times 10^{32}$ gauss cm^3.

Spectroscopic Studies of the Association of Amides in Solution

Richard M. Badger and Hector Rubalcava
California Institute of Technology

To clarify some apparent anomalies in the infrared observations on polypeptides and related substances, a systematic investigation of the simpler amides is being made. Part of a detailed study of the amides in solution will be reported.

In the region of the fundamental N—H frequencies in the infrared the lower unsubstituted amides show essentially identical spectra. In carbon tetrachloride solution it can be shown that the five spectral components attributable to associated molecules must be due to one species, a cyclic dimer. The enthalpy decrease on association is 7900 cals/mole of dimer, or 3950 cals/N—H . . . . O hydrogen bond.

An interpretation is given of the complex structure of the dimer spectrum, and differences between the spectra of the unsubstituted and N-substituted amides are discussed in relation to structure.

Effects of Early Experience on Mating Responses in Male Rats

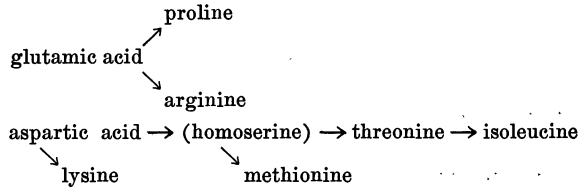
Frank A. Beach and Jerry Kagan, *Yale University*

Male rats were maintained in individual living cages from 36 days of age until the end of the experiment. During the "Conditioning Period" (36th–98th day of age) the animals were divided into four groups and given different kinds of experience. Males in Group I were exposed once each week to a receptive female of their own age, Group II rats were exposed at weekly intervals to a second male, members of Group III were placed once a week in the empty observation cage, and Group IV animals received no conditioning. Beginning at 99 days of age, all rats were given a series of "Critical Tests" with a receptive female. In these tests the groups did not differ significantly with respect to the number of males displaying some copulatory behavior, but the complete mating pattern, including ejaculation, was more than twice as frequent for the males lacking previous contact with other rats (Groups III and IV), than for animals that had been exposed to either males or females during the conditioning period (Groups I and II). Analysis of the data indicated that patterns of social behavior that had been formed before complete mating was physically possible tended to persist in adulthood and partially to inhibit the normal sexual responses.

Synthesis of the Aspartic and Glutamic Families of Amino Acids by *Escherichia coli*

E. T. Bolton, R. Britten, and D. B. Cowie
Carnegie Institution of Washington, Washington, D. C.

The patterns of amino acids synthesized from aspartic or glutamic acids are characteristic and comprise two well-defined families. Relationships between the families and among the members of each have been worked out. For this purpose the isotopic competition method has been extensively employed. This method takes advantage of the fact that labeling of an amino acid, which ordinarily occurs when cells are grown in simple media containing a tagged molecule, may be specifically suppressed by supplementing the medium with an appropriate metabolite. Various cultures have been prepared in this way and analyzed. Specific radioactivity measurements have been made on the amino acids isolated from *E. coli* proteins, and appropriate degradative procedures employed to determine the intramolecular location of tracer isotope. The synthetic sequences found are shown in the scheme below:



The sequences are practically irreversible, although interconversions between aspartic and glutamic acids occur. The amino acids shown constitute nearly 60% of the protein of *E. coli* and account for 90% of the polar side chain amino acid residues.

A General Explanation for the Superficial Aspects of Existing Organic Reefs

Preston E. Cloud, Jr., *U. S. Geological Survey*

A general explanation is possible for the superficial aspects of existing organic reefs. This involves the effects of a recent 6-ft net fall of sea level, coupled with slight recovery from the lowest point of fall. Evidence for the 6-ft fall is found in all tropical oceans. Its cause is seen in renewed growth of ice caps since the postglacial optimum.

The surfaces of reefs that lay within 6 ft of sea level when the 6-ft fall began were subject to truncation by wave erosion and ordinarily support few reef-building organisms today. Conversely, present sites of most flourishing reef surfaces must then have been more than 6 ft below sea level. The low ridge of coralline algae peripheral to many reefs is believed to have grown up from the beveled outer margin with decline of bench reduction and initiation of sea-level recovery. Such factors may also stimulate local renewal of coral growth, especially at reef margins. Tectonic influence locally alters the general scheme.

The comb-tooth pattern of radial grooves and spurs at reef fronts is attributed primarily to abrasion by undercurrents, especially during reduction of elevated reef surfaces. The preponderance of groove systems off windward reefs is related to preponderance of reef islands to windward. Surf-driven water, barred from the lagoon by islands, streams seaward in detritus-laden undercurrents that furrow the reef margin. Organic overgrowth in the noneroding parts of surge channels later obscures the primary erosional effects.

The abundance of habitable low reef islands is also attributed to the 6-ft eustatic fall. If present world temperature increase continues, however, most such islands will disappear again beneath a rising sea in 1000–2000 years.

The Physiology of the Gastric Antrum

Lester R. Dragstedt and Edward R. Woodward
University of Chicago

Previous studies have indicated that the antrum of the stomach provides a hormone for the stimulation of gastric secretion. When the antrum of the stomach is excised in dogs, gastric secretion falls off to a low level, but if the antrum is transplanted into the colon as a diverticulum, a sustained hypersecretion of gastric juice is produced. The development of tension within the antrum as a result of peristalsis stimulates gastric secretion, whereas the application of acid solutions to the antrum mucosa causes inhibition. The possible significance of these findings in the regulation of gastric secretion is discussed.

Preliminary Observations of the Geographical Distribution of Auroras in Alaska

C. T. Elvey, Harold Leinbach, and Joan Hessler
Geophysical Institute, University of Alaska

S. Chapman has pointed out that a new type of diagram showing geographical incidence (overhead occurrence) of auroras, as contrasted with Fritz' diagrams showing the geographical distribution of frequencies of auroral visibility, is needed for theoretical studies.

A program has been set up in Alaska to gather such data and this paper presents a summary of the geographical distribution obtained from previous auroral observations, along with those that have been obtained to date on this program.

A proposed system for the collection of data on a worldwide basis and the recording of this data on punched cards is presented.

Exsolution Phenomena and the Magnetic Properties of Rocks

John W. Graham
Carnegie Institution of Washington, Washington, D. C.

Physical and chemical properties of several Pre-Cambrian diabase dikes having magnetizations opposed to the earth's present magnetic field were studied in an effort to account for the inverse magnetization. The magnetically separable material is an intimate admixture of at least three mineral species: magnetite and maghemite (both strongly ferromagnetic) and ilmenite (essentially nonmagnetic). Experiments to duplicate the magnetic behavior of these rocks during their initial cooling cannot be made owing to the nonreversible conversion of maghemite to hematite at elevated temperature. Maghemite originated in these rocks by low-temperature oxidation of primary magnetite. Magnetization experiments show that the inverse magnetic moment must be attributed to particles having high coercive force, and that there is present, in addition, a significant quantity of essentially demagnetized ferromagnetic material. These observations make it seem reasonable to think that, when these dikes were injected, the earth's magnetic field had its present-day sense, and the reversal of the magnetization resulted from the partial oxidation of a primary magnetite that during cooling had been minutely subdivided by ilmenite exsolution lamellae; the maghemite developed within the magnetite and acquired an inverse magnetization from the fringing external fields of surrounding magnetite particles still magnetized in the original direction; the moment of the sample was thus gradually built up in the reverse direction as the larger particles of magnetite were oxidized and demagnetized. Based on this mechanism, a number of ways can be proposed by which sediments, deposited with the earth's field in its present-day sense, can ultimately acquire an inverse magnetization.

Learning by Rhesus Monkeys on the Basis of Manipulation-Exploration Motives

Harry F. Harlow, *University of Wisconsin*

Psychological motivational theory has emphasized the importance of internal drives as motivational mechanisms. There is every reason, however, to believe that exteroceptive stimuli provide just as basic and important motivational sources as the internal drives. These externally elicited motives are described by such names as curiosity, manipulation, exploration, and play.

Discrimination learning, based on manipulation motives only, has been demonstrated in monkeys. A metal-covered panel holding five pairs of differentially colored screw eyes, one color correct, the other incorrect, was presented to three rhesus macaques. The correct screw eyes were removable, the incorrect screw eyes were fixed and immobile. The monkeys showed progressive and statistically significant improvement in the day-to-day performance on 7 problems, each tested for 4 days. Furthermore, there was no indication of loss of motivational strength throughout 35 test days.

Discrimination learning by monkeys was also demonstrated on the basis of visual exploration. The monkeys were placed in a dimly illuminated cage covered by a box with two windows so designed that they could be covered by differentially colored cards. Selection by the monkey of the incorrectly colored window produced no effect; selection of the correct window was rewarded by permitting the animal to look through the window for a 30-sec period.

All the monkeys learned color discriminations and in one test showed no diminution of visual exploration strength throughout a 4-hr period of continuous testing.

Electrical Responses to Illumination of Isolated Visual Receptor Elements

H. K. Hartline, E. F. MacNichol, Jr., and H. G. Wagner
Johns Hopkins University, Baltimore, Maryland, and *Naval Medical Research Institute, Bethesda, Maryland*

Excitation of the eye by light is accompanied by an alteration of the electric potential difference measured across the layer of visual receptors (retinal action potential). The relation of this action potential to the discharge of optic nerve impulses has been studied in single receptor units (ommatidia) dissected from the eye of an invertebrate (*Limulus*). Electrical responses to light have also been observed in receptor units by means of very small micropipette electrodes thrust into the receptor elements. Apparently, such an electrode often enters one of the sensory cells of the ommatidium; we then observe a resting polarization that is altered by illumination of the ommatidium. Two types of response to light have been observed: rapid, spikelike fluctuations in potential, synchronous with the impulses discharged in the nerve-strand from the ommatidium, and slower, steady depolarizations (pipette electrode becoming less negative with respect to the outside medium). When both types were present at the same time, the amount of depolarization was linearly related to the frequency of the spikes. Often, however, elements were found in which a discharge of spikes occurred in response to illumination, with no perceptible depolarization. In other cases, depolarization took place without any spikes being discharged. Inhibitory effects have also been observed when nearby areas of the eye were illuminated.

A Neutron Diffraction Study of Magnesium Ferrite

J. M. Hastings, L. M. Corliss, and F. G. Brockman
Brookhaven National Laboratory, Upton, Long Island, and *Philips Laboratories, Inc., Irvington-on-Hudson, New York*

Neutron diffraction patterns have been obtained for polycrystalline magnesium ferrite. Magnesium ferrite, a ceramiclike material, is ferromagnetic at room temperature. Néel has proposed a theory based on an uncompensated antiferromagnetism, or ferrimagnetism, which accounts for the observed magnetic behavior of the ferrites. The diffraction patterns which we obtain consist of a superposition of coherent nuclear and magnetic scattering, which may, however, be separated by means of a suitably oriented external magnetic field. The analysis of the nuclear scattering permits a simultaneous determination of the degree of inversion, which for the specimen used is 0.88 ± 0.01, and the u-space group parameter to which the value 0.381 ± 0.001 is assigned. The magnetic scattering can be accounted for only if one assumes antiferromagnetic coupling of the magnetic ions and is found to be in good quantitative agreement with the Néel model. The form factor for the magnetic scattering is, within experimental error, identical with that previously obtained for nickel ferrite. The predicted saturation magnetization based upon the diffraction data is in very good agreement with the experimentally measured value.

Serological Reactivity of Synthetic Polyglucoses

Michael Heidelberger and Alan C. Aisenberg
College of Physicians and Surgeons, New York

Synthetic polyglucoses, prepared by heating glucose in the presence of condensing agents, were found to give specific precipitates with antibodies in a number of antipneumococcus horse sera. Qualitative tests were particularly strong in antisera to pneumococcal Types II, IX, XII, XX, and XXII. Quantitative analyses demonstrated that type-specific antibodies and antibodies to the species-specific "C" polysaccharide were responsible for the reactions. From one third to one half of the antibody could be precipitated from antisera to Types IX, XII, XX, and XXII by the fractions most easily separable from aqueous solution by means of alcohol and therefore presumably those of largest molecular size. Fractions obtained at higher concentrations of alcohol, or degraded by means of partial hydrolysis, precipitated less antibody and gave precipitates in fewer antisera than the first fractions. Two bacterial dextrans and a partial hydrolytic product of a dextran gave somewhat similar reactions. Chemical implications of the data are discussed.

Immunological Specificity of Polyglucoses of Plant and Animal Origin

Michael Heidelberger, Alan C. Aisenberg, Gerti T. Cori, W. Z. Hassid, and Eugene Pacsu
College of Physicians and Surgeons, New York, Washington University School of Medicine, University of California, Berkeley, and *Princeton University*

Glycogens from corn, oysters, rat liver and carcass, rabbit liver, and dog liver gave specific precipitates in the cold with antibodies developed in the horse to the pneumococcal Types II, IX, XII, XX, and XXII. These sera were also the ones which reacted most strongly with synthetic polyglucoses and dextrans. Saliva destroyed the serological reactivity of corn and oyster glycogens, the only ones so tested. Amylopectins and a limit dextrin also gave precipitates, but of smaller size. Unstable amylose solutions prepared by solution of amylose in alkali, neutralization, and dilution precipitated normal sera nonspecifically, but appeared to give heavier precipitates in antisera to pneumococcal Types IX, XII, and XXII than in other sera. Quantitative, as well as qualitative, data on the reactions are given. Limited deductions appear warranted as to the relation between chemical constitution in the polyglucose group and immunological specificity.

The Worldwide Gravity Program of the Columbus Group

Weikko A. Heiskanen, *Ohio State University*

The primary objectives of geodesy are the determination of the dimensions of the best reference ellipsoid for the earth and the establishment of accurate control points for map making. The triangulation in conjunction with astronomical observations can determine the size and

shape of the earth as well as the coordinates of the triangulation points. However, as triangulations cover only a small part of the continents and fail completely over the oceans, many geodetic systems exist. The discrepancy between two systems at points common to both can be as great as 500–2000 meters, because sea level (geoid) does not agree with any adopted reference ellipsoid. To convert to one common system for the whole earth, the undulations of the geoid N, and the components of the deflections of the vertical, ξ and η, must be determined at the initial points of different geodetic systems.

The gravimetric method can give N, ξ, and η, but it also yields much more. Combined with the astronomical observations, it gives without triangulation the necessary control points for mapping. Combined with the existing arc measurements, it checks the dimensions of the adopted reference ellipsoid. The only prerequisite is a sufficiently dense net of gravity stations.

With these advantages of the gravimetric method in mind, and encouraged by the results obtained particularly in Finland, Great Britain, the Netherlands, Russia, and the United States, the worldwide gravity program of the Columbus Group was established 2½ years ago. The progress of this project, as well as the necessary steps for its full-scale realization, are discussed.

The Photoperiodic Reaction

Sterling B. Hendricks and H. A. Borthwick
U. S. Department of Agriculture, Beltsville, Maryland

The photoreaction controlling photoperiodism in plants, germination of some seed, etiolation changes in seedlings, and many other morphogenic responses is found to be the reversible isomerization of the light-sensitive pigment. Time measurement in photoperiodism is accomplished by the dark reaction of the infrared-absorbing form changing to the red-absorbing form. The isomerization, by way of illustration, can well be of a cis- to a trans-modification. In any case, the photoexcited state is common to the two modifications of the pigment. Evidence is given that the biological response of a sample population varies either with the amount of one pigment or with the ratio of the two pigments. Progress has been made on measuring by physiological response the overlapping absorptions for the two forms in the blue-violet part of the spectrum relative to the previously measured absorptions at longer wavelengths where the overlap is not confusing.

The Reduction of Radiation Damage to Living Cells by Treatment after Exposure

Alexander Hollaender, G. E. Stapleton, and Daniel Billen
Oak Ridge National Laboratory

Postirradiation recovery after exposure to massive doses of x-rays of certain strains of mice has been observed after transplantation of nonirradiated spleen (Jacobson) or bone marrow (Lorenz). No cell-free extracts have been found to stimulate the spleen or spleen brei transplantation. A somewhat different approach—i.e., incubation of x-irradiated bacteria in the presence of yeast or meat extracts at suboptimal temperatures—has shown significant increase in viable cells. The optimal recovery temperature varies with different strains of *Escherichia coli*: for B/r, 18° C; Crook, 12° C; and Texas, 21° C—lower than optimum growth temperatures for all three strains; also the total oxygen consumption of irradiated cells is increased at suboptimal temperature incubation. The recovery is much less pronounced if the cells are irradiated in the absence of oxygen. The nutritional factors that favor recovery can be purified from several source materials by paper chromatography or alcohol extraction. These factors apparently consist of several constituents which, when used together, are highly effective, are not proteins, are water-soluble, and are acid- and heat-stable. Assay methods developed will detect less than 0.1 μg/ml of yeast extract.

This type of recovery has not been observed after ultraviolet irradiation; however, after exposure to short ultraviolet (< 3000 A), it is possible to demonstrate, (*a*) a dark recovery, and (*b*) a light recovery called photorecovery, which is brought about by the long ultraviolet and near-visible regions of the spectrum (Kelner). Photorecovery has not been demonstrated after x-irradiation. Although it may appear at first sight that all types of radiation produce the same final effect, the results of studies involving treatment after irradiation show that the x-ray and ultraviolet regions each produce distinct and different patterns of effects.

Mechanism of Regression of Mammary Cancers after Adrenalectomy

Charles Huggins and Thomas L-Y. Dao
University of Chicago

Widespread mammary cancers of humans often undergo extensive and prolonged regression after the adrenal glands have been removed; other types of breast cancer remain uninfluenced. The most responsive tumors are those where the neoplasm forms tiny luminated glands recognizable on cytologic examination; frequently secretion is observed in these acini. The syndrome of adrenal-responsive mammary cancer is associated with a considerable excretion of estrogen in the urine, even when the ovaries had been removed prior to the onset of the cancer or when the patient was postmenopausal and had no ovarian function; adrenalectomy under these circumstances abolishes the excretion of estrogen. The mechanism of regression after adrenalectomy consists in the elimination of hormones formed in the adrenal, of types similar to those normally found in the ovary. An essential parameter in the process is sufficient maturity of the neoplastic cells that they can respond to withdrawal of these hormones and consequently involute.

The Neutron-Electron Interaction

D. J. Hughes, *Brookhaven National Laboratory*

Slow neutrons, although uncharged, are expected to exhibit three distinct interactions with the electrons of an atom. The magnetic interaction with the spin magnetic moment of the electron is large and well understood, the relativistic interaction between the neutron moment and the electron charge is much smaller and has been only recently evaluated, and the electrostatic interaction between the electron and the meson cloud of the neutron is the smallest and least understood of the three. Because of the importance of this last interaction to meson theory, and in spite of its smallness, three neutron-optical experiments have been devised for its measurement. In all the methods the interference among neutron waves scattered from the electrons is used to isolate the electron interaction from the much larger nuclear scattering. At Argonne (Fermi, Marshall, Hamermesh, Ringo, Wattenberg), the angular variation of scattering from noble gases was used to identify the electronic

effect, and at Columbia (Rabi, Havens, Rainwater), the same information was obtained from the variation of scattering with neutron wavelength. Recent measurements at Brookhaven (Hughes, Harvey, Goldberg, Stafne) have utilized mirror reflection of neutrons to give a greatly increased sensitivity. Highly collimated neutrons were reflected at a grazing angle of a few minutes from the interface of polished bismuth and liquid oxygen. All measurements show that the meson cloud effect is small, the Brookhaven result giving an interaction well depth (for an e^2/mc^2 range) no more than 200 v, a result much less than is expected from current meson theory.

Effect of Photic Stimulation in Visual Pathways from Retina to Cortex

Donald B. Lindsley, ***University of California, Los Angeles***

This exploratory study had two general purposes: To determine the role of central mechanisms in vision; and to form a background for interrelating neurophysiologic and psychologic data in experiments on human perception.

Electrical responses were recorded simultaneously from several sites in visual pathways and cortical areas in the cat during repetitive photic stimulation. Recording sites included retina, optic tract, lateral geniculate body, optic radiations, visual cortex I and II, and nonvisual cortex. Stimulus parameters involved light-dark ratio, intensity, wavelength, frequency, and duration of flash. Subcortical electrodes were positioned by the Horsley-Clarke technique. Recording sites were precisely localized by histologic study.

Extensive observations have been made in thirteen successful preparations. Three were under Nembutal or chlorolosane anesthesia; the remainder were unanesthetized, but decerebrated preparations.

The results permit differentiation of visual and nonvisual areas cortically and subcortically. The retina, optic tract, and lateral geniculate body respond discretely, with varying patterns, to frequencies of stimulation up to and over 100/sec, whereas specific areas of the visual cortex fail to follow the stimulus beyond about 40/sec. This suggests a possible mechanism of visual fusion. Interesting differential effects to monochromatic light have been obtained, with maximal response to yellow and blue-green and minimal or no response to red. Intensity, duration of flash, and light-dark ratio each produced modifications in subcortical and cortical responses. The significance of the results for visual theory and for further experimentation are discussed.

A General Theory of Convergence

E. J. McShane, ***University of Virginia***

By a syntax we shall mean a system of f, X consisting of (a) a function f on a domain D_f, and (b) a nonempty family X of nonempty sets such that if X_1 and X_2 belong to the family X, there exists an X_3 in the family which is contained in X_1 and in X_2. The syntax f, X *converges into* a family Y of sets if to each Y of the family Y corresponds X in X such that when x is in X, $f(x)$ is in Y. The resulting theory of limits includes the theory of filters and Moore-Smith convergence in a straightforward manner, and therefore includes all the well-known special types of convergence. It leads to simple proofs of basic limit theorems in analysis and topology. The topological applications—for example, in characterizing compactness—are the same as those of the other theories.

Electron Interferometry

L. Marton, J. Arol Simpson, and J. A. Suddeth
National Bureau of Standards

An interferometer has been constructed which operates with electron beams and produces a system of fringes in the viewing instrument. The appearance of the fringes can be varied at will by changes in the (electron) optical path. Such changes can be introduced either by mechanical means (displacement of the optical elements) or by electromagnetic means (changing of the refractive index). Calculations of fringe spacings, based on light optical analogies, show good agreement with the observed spacings.

The instrument belongs in the category of "wide-beam" interferometers: beam-splitting is achieved by amplitude splitting as in the Mach-Zehnder-type instrument of light optics. In absence of "true" reflection for electrons, diffraction on thin crystal lamellae was chosen as the beam-splitting process. A peculiarity of this kind of beam-splitter is that it produces an "achromatic" instrument; that is, its fringe system is independent of the spectral composition of the radiation emerging from the source.

The production of a fringe system by such an instrument shows that the analogy between the physical optics of photons and of electrons is valid over a wider range of experiments than has been generally assumed. Further plans call for improvements in the performance of the instrument and its application to different problems in physics.

The Interpretation of the Kinetic Constants of Systems Envolving α-Chymotrypsin

Carl G. Niemann, ***California Institute of Technology***

The α-chymotrypsin catalyzed hydrolysis of a number of simple synthetic specific substrates can, under certain circumstances, be described in terms of equation (1) where $K_S = (k_2 + k_3)/k_1$. Since this process can be considered

$$E_f + S_f \underset{k_2}{\overset{k_1}{\rightleftharpoons}} ES \xrightarrow{k_3} E_f + P_{1f} + P_{2f} \qquad (1)$$

to be dependent upon two factors—i.e., the affinity of the enzyme for a particular specific substrate and the susceptibility to subsequent reaction of the corresponding intermediate enzyme-substrate complex—it becomes desirable to be able to evaluate the dissociative constant of ES—i.e., k_2/k_1 from the experimentally determinable values of K_S and the so-called specific rate constant k_3. As this can be done only when $k_3 \ll k_2$, it is important to recognize those types of specific substrates wherein this situation prevails and those wherein it does not. On the basis of extended observations on the kinetics of hydrolysis of a variety of simple synthetic specific substrates and the behavior of enantiomorphic and structurally analogous competitive inhibitors, and on the basis of the pH dependency of the K_S and k_3 values of the specific substrate tyrosinhydroxamide, it can be shown that $K_S \doteq k_2/k_1$ for a number of acylated α-amino acid hydrazides and amides and a representative α-amino acid hydroxamide, but that K_S is probably not equal to k_2/k_1 for the acylated α-amino acid hydroxamides, and is certainly not equal to k_2/k_1 for the majority of the acylated α-amino acid esters.

Dielectric Increments in Aqueous Solutions of Synthetic Polyelectrolytes

J. L. Oncley, H. M. Dintzis, and R. M. Fuoss
Harvard University and *Yale University*

Measurements of the dielectric constant and conductance of aqueous solutions of poly-4-vinyl-N-*n*-butyl pyridinium bromide have been made at 0° and 25° C over the frequency range from below 10,000 to 4,000,000 c/sec and the concentration range from 2.4 to 0.05 g/liter. The polyelectrolyte preparation used was a middle fraction with number average molecular weight of the order of 500,000.

Because of the polarization capacity resulting from the high conductance of these solutions (specific conductance from 320 to 6 μmhos/cm), and the wide dispersion region of this polymer, it has been difficult to obtain quantitative values for the dielectric increments of these solutions. The dielectric constant shows marked frequency dependence above 100,000 c/sec and surprisingly little concentration dependence. At the lowest concentrations and at frequencies below 100,000 c/sec, the polyelectrolyte yields dielectric increments of several hundred dielectric constant units/g/liter. These increments are 100–1000 times those observed for globular proteins, and amino acids and peptides.

Measurements of the increase in conductance at high frequencies are consistent with these high dielectric increments, and also indicate much heterogeneity in regard to relaxation times.

There are many points of similarity between these measurements and those of G. Jungner, I. Jungner, and L.-G. Allgen on the dielectric constants of aqueous solutions of sodium thymonucleate. Both materials show large deviations from the usual linear dependence of dielectric constant upon concentration above 0.05 g/liter, and a shift to smaller relaxation times as the concentration is increased. Dielectric increments and relaxation times are of the same order of magnitude as the higher molecular weight nucleic acid salts. The thymonucleate solutions show a more homogeneous behavior in regard to relaxation times, however, as might be expected in view of the heterogeneous nature of the preparations studied here.

Species Differences in Taste Sensitivity

Carl Pfaffmann, *Brown University*

The sense of taste in three species, the rat, rabbit, and cat, was studied by recording the sensory nerve impulses from the tongue. The chorda tympani nerve in anesthetized animals was dissected free and placed upon wick electrodes connected to an amplifier and cathode-ray oscillograph recording unit.

In all species the nerve showed varying amounts of resting activity. This was most pronounced in the rabbit. Application of chemical solutions to the tongue produced a maintained asynchronous discharge of impulses. The discharge returned to the resting level when the tongue was rinsed. Thresholds ranged from low to high, in order, for quinine, hydrochloric acid, sodium chloride, and sucrose. In all species the acid and salt produced significantly more neural activity than did quinine or sucrose. The response to hydrochloric acid in the three species was very similar. Quinine gave relatively more response in the cat, whereas sucrose gave relatively more response in the rabbit and the rat. The more striking differences were noted in the relative effectiveness of salts. Whereas sodium chloride was much more effective than potassium chloride in the rat, this relation was reversed in the cat and rabbit. In the rabbit especially, potassium chloride was more effective than sodium chloride.

The results emphasize that any general theory of taste must take species differences into account.

Electron Distribution in Molecular Hydrogen

Norman F. Ramsey, *Harvard University*

Due to the second order paramagnetism term in the theory of molecular diamagnetic susceptibility, measurements of the magnetic susceptibility of H_2 do not directly determine the mean square distance, $< r^2 >$, of an electron from the midpoint of the molecule. However, the second order paramagnetism term has been experimentally determined from molecular beam measurements of the rotational magnetic moment. When this result is combined with Havens precision values of the diamagnetic susceptibility of H_2, a value for $< r^2 >$ of $(0.7258 \pm 0.0022) \times 10^{-16}$cm^2 is obtained for H_2 molecules in the first rotational state. The error in this determination could be reduced by a factor of ten if there existed equally precise data on the susceptibility at a much different temperature. From molecular beam experiments, the dependence of the molecular diamagnetic susceptibility upon molecular orientation has been measured, and from this the quadrupole moment of the electron distribution has been inferred. When the quadrupole data is combined with the above value for $< r^2 >$ and when the z axis is taken along the internuclear line, the principal second moments of the electron distribution in molecular H_2 are found to be $< x^2 > = < y^2 > = (0.2144 \pm 0.0015) \times 10^{-16}$cm^2 and $< z^2 > = (0.2969 \pm 0.0022) \times 10^{-16}$cm^2.

Behavior Cycles in Man and Animals

Curt P. Richter, *Johns Hopkins Hospital*

For the study of behavior cycles in man we need daily observations and records of behavior over long periods of time. Psychiatric clinics offer the best opportunity for obtaining such observations and records.

At the Phipps Psychiatric Clinic I have found records of patients who showed very regular cyclical changes in behavior, changes between normal and most abnormal behavior, between depression and elation, between stupor and excitement. The frequency of the cycles ranged from 2 to 40 days. For each patient the cycles had a definite frequency.

Little or nothing is known about the origin of these behavior cycles in man. We have attempted to throw light on their origin through studies on the experimental production of cycles in animals.

The rat lends itself best of all for such studies, since daily records can readily be made of its gross bodily activity (running in a revolving drum), food and water intake, body weight, and vaginal smears.

We have produced regular behavior cycles by interfering with the endocrine glands: a 30–40-day cycle by thyroidectomy or by thyroid injury through treatment with I^{131} or sulfamerazine; a 20-day cycle by parathyroidectomy; a 14-day cycle by pituitary stalk section; a 90-day cycle by removal of one ovary and all except a small remnant of the other ovary.

Cycles were produced in wild Norway rats by severe stress or by captivity.

This knowledge may be of help in the understanding of the origin of behavior cycles in man.

The Role of the Tricarboxylic Acid Cycle in Amino Acid Synthesis in *Escherichia coli*

R. B. Roberts and P. H. Abelson
Carnegie Institution of Washington, Washington, D. C.

The amino acid synthesis of *E. coli* growing with glucose as the principal energy source has been studied, using various C^{14}-labeled compounds. Under these conditions 35% of the total carbon assimilated is incorporated by way of the tricarboxylic acid cycle which leads to the synthesis of aspartic acid, glutamic acid, and the group of amino acids derived from them.

The rates of flow in the various branches of the cycle have been determined, using $C^{14}O_2$ as a tracer. In exponentially growing cultures the cycle produces 19 μmoles of aspartic acid and 16 μmoles of glutamic acid/min/g dry cells. Seventy per cent of the aspartic acid is derived from carbon that has just entered the cycle, and 30% from carbon that has passed around the cycle. This flow pattern predicts for other experiments precisely the distribution of C^{14} observed in aspartic acid and glutamic acid when $C^{14}H_3COOH$, $CH_3C^{14}OOH$, and C^{14} glucose are used as tracers.

The carbon efficiency of the cycle is high; only 25% of the total carbon entering the cycle is converted to CO_2. The net CO_2 output of the cycle accounts for only 2% of the total CO_2 produced from glucose.

It appears that the Krebs tricarboxylic acid cycle, which was formulated to describe oxidation in vertebrate tissue, also applies to *E. coli*. However, in these growing cells the cycle is important as a mechanism for amino acid synthesis but relatively unimportant in the oxidation of glucose.

Photon-stimulated Diffusion in Solids

Frederick Seitz, *University of Illinois*

Several decades of research on alkali halide crystals colored by the addition of an excess of alkali metal and by ionizing radiations have established beyond reasonable doubt that the centers producing coloration in the visible part of the spectrum (F-centers) are to be associated with halogen ions which have been replaced by electrons. If the crystals are irradiated with light lying in the absorption band associated with F-centers, in an appropriate range of temperature, some of the electrons are removed from F-centers and transferred to other F-centers, thereby producing F′-centers, which have 2 electrons instead of 1, and vacant halogen ion sites (negative-ion vacancies). Delbecq, Pringsheim, and Yuster have recently identified two new absorption bands, in the far ultraviolet at the edge of the fundamental absorption bands of the crystals, that are correlated with halogen-ion vacancies and with F-centers. These bands, termed the α and β bands, respectively, are now believed to be associated with absorption of light by the halogen ions in the vicinity of the centers and the production of excitons trapped at the centers. Very recently Martienssen has shown that the intensity of the α band can be diminished by irradiating the crystal with light absorbed in the α band. The quantum yield is low. This diminution has been observed at liquid nitrogen temperature where the rate of diffusion of the halogen-ion vacancies as a result of normal thermal fluctuations is presumed to be completely negligible. It seems necessary to assume that lattice vibrations of large amplitude, stimulated at the halogen-ion vacancies as a result of absorption of light quanta, promote diffusion of the vacancies and allow them to disappear or join clusters. This process could, in principle, occur even at the absolute zero of temperature and suggests a mechanism whereby other transport phenomena can be induced by radiation at low temperatures.

Theory of the Atomic Beam Resonance Method for Excited States

Robert Serber, *Columbia University*

An atomic beam resonance method for studying atoms in excited states has recently been described by Rabi. The atoms are raised to excited states by illuminating them with their resonance radiation, and transitions between these states are induced by a radiofrequency field before they drop back to the ground states. Denote the ground states by an index τ, the excited states by m; suppose that initially the atom is in the state $\tau = 0$, and that the angular frequency of the radiofrequency field, ν, is nearly equal to ν_{21}, the frequency difference between two excited states $m = 1$ and 2. A simple argument suffices to obtain the resonance formula for the relative probability, P_τ, that the atom will fall back to the state τ,

$$P_\tau = \frac{1}{\gamma}\left\{\sum_m \gamma_{m\tau}\,\sigma_{m0} + \frac{1}{2}(\gamma_{2\tau} - \gamma_{1\tau})(\sigma_{10} - \sigma_{20})\,\frac{|U_{21}|^2}{(\nu - \nu_{21})^2 + \gamma^2 + |U_{21}|^2}\right\}.$$

Here $\gamma_{m\tau}$ and σ_{m0} are the spontaneous and induced widths for transitions between the indicated states, $\gamma = \sum_\tau \gamma_{m\tau}$, and $\frac{1}{2}\hbar U_{21}$ is the matrix element of the interaction energy with the radiofrequency field.

A more systematic derivation of the intensity formula has now been carried out, which makes clear the various effects neglected in the simple derivation, and permits evaluation of these effects if greater precision is desired. Among the effects we may list the influence of the frequency spectrum of the resonance radiation, the induced widths of the levels due to the stimulated emission caused by the resonance radiation, the line shifts produced by the fields of the resonance and radiofrequency radiation, effects of the variation of matrix elements with frequency, antiresonance terms in the interactions of the resonant levels with the radiofrequency field and nonresonance interactions with other states, and the possibility of multiple emission and absorption of radiofrequency photons.

Problems of Gene Structure. II, Separation of R^r Elements (S) and (P) by Unequal Crossing Over

L. J. Stadler and M. G. Nuffer, *University of Missouri*

In cultures heterozygous for a heterochromatic appendage of chromosome 10 (designated K10), mutation of *R* is sometimes associated with crossing over. The compound *G* R^r: Cornell $(k)/g$ R^g: Queens *K*, in a test of 70,140 ♀ gametes, yielded 12 seed color mutations of *R*, of which 5 were crossovers between *R* and *K*, and 7 were not. Standard crossover frequency for the R^r-*K* interval is about 1%.

Assuming the constitution (P) (S) for R^r: Cornell and (p) (S) for R^g: Queens, the crossovers would have to be unequal to cause loss of (S). However, this is not critical evidence for unequal crossing over, for with other assumptions of elementary constitution of the two alleles, the loss of seed color effect could be produced by equal crossing over.

The gene *Er*: Cornell was transferred to the K10 chromosome, and mutation behavior studied in the compound *G Er*: Cornell (*k*)/*g Er*: Cornell *K*. Here crossovers resulting in loss of seed color or plant color effect must be unequal, whatever the elementary constitution assumed. Of the 13 seed color mutants identified among 74,056 ♀ gametes tested, 5 were crossovers between *G* and *K* and 8 were not. Of the 5 plant color mutants among 58,785 ♀ gametes tested, all were crossovers between *G* and *K*. Standard crossover frequency for the *G-K* interval is about 15%.

The frequency of "crossover-mutants" is similar in the 3 determinations (about 7/100,000 gametes). This frequency is superimposed upon a varying frequency of mutations independent of crossing over. In the homozygous *Er*: Cornell culture studied this was about 13/100,000 gametes for seed color mutations and 0 for plant color mutations.

Thus the determiners designated (S) and (P) are physically separable genic elements, which are probably synaptically homologous. Their order with reference to *G* and *K* is *G* (P) (S) *K*.

Current Research on the Cosmical Abundances of the Elements

Otto Struve, *University of California, Berkeley*

Recent investigations at Berkeley have shown that the chemical compositions of binary star components, having identical masses, are the same to within less than about 20%, in terms of numbers of atoms. Similar conclusions, though less precise, have previously been obtained for stars in galactic clusters having identical luminosities. At the other extreme are systems composed of a normal star and of a planetlike satellite similar to Jupiter, which differ enormously in the relative abundances of hydrogen and other light elements. It is probable that intermediate systems with mass ratios of the order of 10: 1 or of 100: 1 may also show appreciable differences in the compositions of the atmospheres of the components.

These results are reviewed in the light of previous work on the relative abundances of hydrogen to metals in young stars of Population I and old stars of Population II. Attention is called to a remarkable contradiction between results obtained for yellow and red giants and dwarfs on the one hand, and blue pulsating stars on the other: The former seem to indicate a high abundance of hydrogen, whereas the latter definitely suggest a low atmospheric abundance of hydrogen.

The purpose of this paper is to demonstrate the importance of a cooperative plan for research, taking into account the conclusions of nuclear physicists, and coordinating these conclusions with the vast mass of scattered astronomical determinations. It is probable that processes other than nuclear ones are responsible for many, if not all, the observed differences in the present atmospheric compositions of the stars. However, there are a number of *indications* that nuclear processes may produce not only large-scale effects, such as the conversion of hydrogen into helium, but also occasional processes involving the production of heavy atoms.

The Origin of Soluble Substances on the Earth's Surface

Harold C. Urey, *University of Chicago*

Goldschmidt has explained the high abundance of certain elements—i.e., Cl, Br, B, and S—as due to their volatilization at high temperatures as the earth was formed. However, other elements should be as volatile or even much more volatile than these, and are not concentrated at the earth's surface. Hg and As are particularly volatile, F is about as volatile as Cl, and in a reducing atmosphere Cd and even Zn should be volatile. The distribution of elements does not agree with Goldschmidt's hypothesis. Compounds of Cl, Br, and B are soluble in water, whereas those of the other elements mentioned are not. Iodine should belong in this group, but the data are incomplete. Various hypotheses relative to the origin of this regularity are discussed. It is concluded that the outer 100 km or more of the earth accumulated at sufficiently low temperatures to permit liquid water at its surface. No satisfactory way for the inclusion of nitrogen in igneous rocks at high temperature is found, but its inclusion as ammonium salts from primitive oceans agrees with the published data exactly. S was present as H_2S in nonequilibrium amounts because of temporary high temperature processes (i.e., collisions) and slow reaction with ferrous oxide and silicates at the low prevailing temperature. Carbon was present as CH_4 in the primitive atmosphere, and complex organic compounds appeared before the earth was completely formed.

On a Theory of Conditional Equations in Finite Fields

H. S. Vandiver, *University of Texas*

Consider the congruence

$$x^m + ay^n + b \equiv 0 \pmod{p}, \qquad (1)$$

with a, b, m, and n given integers, p a given prime with $xyabmn \not\equiv 0 \pmod{p}$. This statement is equivalent to saying that the expression on the left must be exactly divisible by p, and we may examine the possible values of integers x and y that will bring this about. To attack the problem in general it seems convenient to take initially classes of congruences of the type (1), and first we may keep a, b, m, and n fixed and let p range over the set of primes. This particular problem has been extensively studied, and limits have been found for the number of possible sets (x, y) by Mordell and others. N. C. Ankeny and the writer have obtained results concerning the classes of congruences (1) when a, b, and p are fixed but $m = n$, with m ranging over the set of positive integers. The writer has also recently obtained some theorems concerning the class obtained when p ranges over the set of primes with a and b fixed and mn a multiple of $(p-1)$.

One generalization of (1) is obtained from an analogous equation in finite fields in lieu of a congruence. Another is obtained by increasing the number of unknowns as far as we please.

The Collective Model of the Nucleus

John A. Wheeler, *Princeton University*

An individual particle moving through the nuclear interior experiences at the nuclear surface a sharp change in potential, as a consequence of which a strong coupling is set up between the given particle and other nucleons. This coupling leads to the existence of collective modes of oscillation of the nucleus, in which the boundary undergoes displacements that are periodic in time (capillary oscillations). Starting from the idealization of perfect saturation of nuclear forces, one arrives at a picture—the

collective model of the nucleus—which unites many of the features of the independent particle picture and the liquid drop model. There is a close analogy with molecular physics. In the one case a given assignment of electrons to orbital states determines a characteristic potential energy curve or surface for the vibration of the diatomic or polyatomic molecules. In the other case, the state of the nucleons fixes the potential energy as a function of the parameters which describe the collective oscillations. Slipover from one surface to another near a point of contact is a mechanism fundamental for the exchange of energy between collective motion and individual particle excitation. The Franck-Condon principle has important consequences for the mechanism of typical nuclear processes. The collective model has important implications for the values of nuclear quadrupole moments, and for the rates of typical nuclear reactions.

Pulmonary Blood Flow at High Altitudes

Carl J. Wiggers, Albert Hurlimann, and Philip W. Hall, III
Western Reserve University School of Medicine

It is, of course, well known that the blood is incompletely oxygenated (anoxia) at high altitudes, owing to the low pO_2 of the atmosphere. Attention has recently been called to the fact that anoxia constricts pulmonary vessels. This could be interpreted as an impediment to pulmonary blood flow, resulting in transport of less hypoxic blood to the tissues.

Several types of rebreathing experiments were carried out on dogs to determine whether such a circulatory factor operates. In a first series, the effects of progressive anoxia were deduced from changes in pressure pulses recorded simultaneously from the aorta, left atrium, and pulmonary artery. The conclusion was drawn that both ventricles expel more blood per beat. Since the heart also accelerates, the cardiac output/min increases. This could not happen if pulmonary blood flow were reduced. In a second series, it was shown by use of a flowmeter that increased pulmonary blood flow averaged 26% during a degree of anoxia corresponding to that produced at an altitude of 19,000 ft. In a third series, it was shown that the augmented flow occurs despite the induction of augmented pulmonary vascular resistance; but the elevation of pulmonary pressure occasioned by greater right ventricular output physically overpowers this constriction action. In a fourth series, the opinion of some previous workers, that the site of increased resistance lies beyond the alveolar capillaries, was confirmed. Hence, oxygenation of blood in the alveoli would not be impaired. The conclusion is drawn that cardiac stimulation by anoxia even compensates to some extent for the decreased oxygen saturation of blood by transporting larger volumes to the tissues.

Suppression of Spontaneous Tumors of Mice through the Considered Use of Antimetabolites

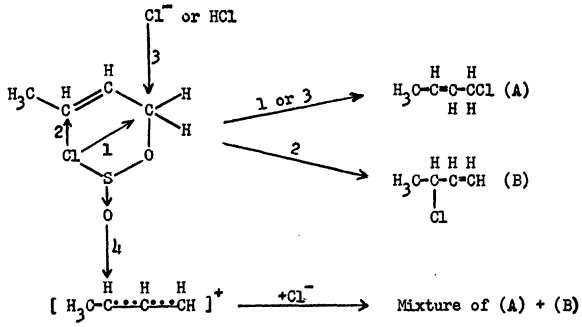
D. W. Woolley
The Rockefeller Institute for Medical Research

The study of the basis of selective action—i.e., of why a given chemical is poisonous to one living thing and harmless to another—has indicated that selective drugs can be predicted and realized through the application of existing biochemical and nutritional knowledge. Thus it can be shown that those cells which synthesize vitamin B_{12} and riboflavin are harmed by suitable antimetabolites of 1,2-dimethyl-4,5-diaminobenzene, the common precursor of these vitamins. Those cells which do not conduct these syntheses and therefore exhibit a nutritional need for these vitamins, are not affected. Because spontaneous mammary tumors of mice have been found to synthesize vitamin B_{12} in contrast to the inability of normal tissues to do likewise, the aforementioned antimetabolites of dimethyldiaminobenzene should selectively harm the neoplasms. Three of these antimetabolites have been shown to cause these spontaneous cancers to become smaller and occasionally to disappear. The substances are 1,2-dimethyl-4-amino-5-hydroxybenzene, 1,2-dichloro-4-(*p*-nitrobenzenesulfonylamido)-5-nitrobenzene, and 1,2-dimethyl-4-(*p*-carboxyphenylazo-)-5-hydroxybenzene. Not all individuals were benefited, and, in fact, only about 50% of animals exhibited regression or disappearance of the tumors. Furthermore, the regressions of the neoplasms were not permanent. All eventually began to grow again in 1–5 months. Studies were made in an effort to ascertain why the tumors became resistant to the drugs, and why all were not originally susceptible.

The Controlled Conversion of Allylic Alcohols into Chlorides with Thionyl Chloride

William G. Young, Fred Caserio, and David Brandon, Jr.
University of California, Los Angeles

The reaction of thionyl chloride with γ- and α-methylally alcohols has been studied under carefully controlled conditions to determine the effect of solvent, temperature, order of addition, and amines on the ratio of the various reaction paths 1, 2, 3, and 4 shown below for the γ methyl isomer.



These paths lead to the production of pure A, pure B, or a mixture of the two. With no solvent, 80% of the starting allylic alcohol is converted by Path 2 into the chloride of its allylic isomer. The addition of pyridine to the alcohol removes the possibility of Paths 1 and 2 and leads to the production of the same mixture of A and B from both allylic alcohols, presumably by Path 4. When ether is used as a solvent to tie up hydrogen chloride, each allylic alcohol is quantitatively converted into its isometric allylic chloride by Path 2. The introduction of a relatively much stronger base such as tributylamine apparently favors the quantitative operation by Path 3. If this controlled formation of known products can be extended to all allylic alcohols the procedures used should become invaluable in the study of natural products and in organic synthesis.