and tissues, and possibly in monitoring the steady state appropriate to a particular metabolic function.

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National Academy of Sciences

Abstracts of Papers Presented at the Autumn Meeting

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Semiempirical Study of the H_2Cl Transition Complex through the Use of Hydrogen Isotope Effects

Jacob Bigeleisen and Max Wolfsberg,
Brookhaven National Laboratory

Linear and triangular structures for the H_2Cl transition complex have been analyzed in terms of normal vibration theory and by an evaluation of the experimental data on the effect of hydrogen isotope substitution on the rate of reaction of hydrogen molecules and chlorine atoms. The frequencies of the bending vibrations are probably small enough that their contribution to the relative rates can be expressed in terms of a small quantum correction of the order of $(hc/kT)^2\ (\omega_{H}^2-\omega_{D,T}^2/24)$. The near classical behavior of the bending frequencies for both linear and triangular structures of the H_2Cl complex serves to reduce the ratio of the frequency factors, $A_H/A_{D,T}$, in the Arrhenius equation from that expected from structural considerations alone. Quantitative agreement is found between the caluculated and experimentally determined frequency factor ratios.

The "symmetrical" stretching frequencies, for both linear and triangular complexes, respectively, have been evaluated from the relative rates of reaction of H_2 and HT with chlorine atoms at 0°C and the known properties of the isotopic hydrogen molecules. This empirically evaluated parameter together with thermodynamic data and an estimate of the tunnel correction suffice to calculate the relative rates of reaction of the isotopic hydrogen molecules with chlorine atoms as a function of temperature. Good agreement is found between the calculated rates for both linear and triangular structures and the available experimental data on HD, D_2, and HT.

Work was performed under the auspices of the U.S. Atomic Energy Commission.

Diffusion and Sedimentation of a Weak Polyelectrolyte, Carboxymethyl Amylose (CMA)

Charles O. Beckmann and Anthony G. Scott,
Columbia University

The diffusion curve (dc/dx vs. x) of CMA solution against water is not of the ideal Gaussian form but possesses a shoulder on the solvent side of the boundary. This anomaly has also been observed for the nucleic acids. Analysis shows the diffusion coefficient (D) to be a complicated function of the concentration, rising sharply as the concentration increases from zero, going through a maximum, decreasing to a minimum and then rising very slowly.

These variations stem from the superposition of two effects that arise from the increase in ionization with decreasing concentration. On the one hand, the increase in negative charge on the polymer molecule causes its extension owing to intramolecular repulsions and, hence, a decrease in D. On the other, the increase in number of more rapidly diffusible hydrogen ions increases the drag on the polymer molecule and, hence, causes an increase in D. The former mechanism dominates the situation in very dilute solution, as is substantiated by viscosity measurements, and the latter dominates the situation in intermediate concentrations.

The effects are reflected in the appearance of the sedimentation curves of CMA which show two almost resolvable peaks, which in this case, however, do not indicate the presence of two molecular species. The effects described can be suppressed by a sufficiently high concentration of salt.

Natural Occurrence of Polyacetylene Compounds

Marjorie Anchel, *New York Botanical Garden*

Polyacetylene compounds from biological sources were almost unknown until a few years ago when occurrence in higher plants and in fungi was reported. A complete series of such compounds, ranging from C_8 to C_{13} has now been isolated. The naturally occurring compounds usually contain double bonds, as well as conjugated triple bonds, and show a variety of functional groupings. Several of the compounds obtained from fungi contain also an allenic grouping and undergo an interesting isomerization, the product of which is not allenic but contains an additional acetylenic group. The metabolic significance of the polyacetylenes is unknown, but a number of them are known to be toxic to microorganisms or to higher animals.

Recent Results on the Heat Capacities of Superconducting Metals at Liquid Helium Temperatures

Henry A. Boorse, *Columbia University*

Detailed measurements have been made of the normal and superconducting heat capacities of Nb, Va, Ta, and La. With some exceptions, the heat capacity in the normal state can be represented in the usual manner by the sum of a Debye term and a Summerfeld term. In the superconducting state none of the afore-mentioned elements displays the usually assumed T^3 dependence. Values of the electronic heat capacity appropriate to the superconducting state are compared with the predictions of the Heisenberg-Koppe theory and with those of the "α-model." The former gives a better fit with the experimental data, but departures at the lowest temperatures appear to be beyond the experimental error.

Superheating of Water as a Measure of Negative Pressure

Lyman J. Briggs, *National Bureau of Standards*

Clerk Maxwell (*Theory of Heat*, 1871) first directed attention to the fact that the superheating of water provides a measure of its negative pressure at high temperatures. Superheated water (or any other liquid) in a tube open to the atmosphere sustains a negative pressure equal to its saturation vapor pressure at the observed temperature, less the pressure of the atmosphere. This interesting fact appears to have been entirely overlooked in recent reviews of the literature of negative pressure.

Defour suspended droplets of water in a mixture of wintergreen oil and linseed oil of equal density, which he heated to 180°C without the water exploding. This corresponds to a negative pressure P_N of about 9 atm. Harvey *et al.*, after subjecting water to a hydrostatic pressure of more than 1000 atm in order to drive gas nuclei into solution, found that water so treated could be superheated in an open tube to 202°C without exploding ($P_N = 16$ atm).

Kenrick, Gilbert, and Wismer, using a thin-wall capillary U-tube the lower end of which was pluged into the bath for 5 sec, superheated water to 270°C ($P_N = 54$ atm). Using a fine butt-welded thermocouple threaded through a thin-wall capillary U-tube, I have confirmed their conclusion that an immersion time of 5 sec is sufficient to attain the temperature of the bath (within 1°C). Using their method I have superheated water to 264°C before it exploded ($P_N = 50$ atm).

Larmor has shown that the negative pressure of water should vanish at 273°C if the van der Waals equation continuously applies; that it does not so apply is evident from the negative pressure of 54 atm at 270°C derived from the superheating measurements. Apparently the only safe assumption is that the negative pressure becomes zero when the meniscus vanishes at the critical point, 374°C.

Circulating Splanchnic Blood Volume

S. E. Bradley, B. Cominsky, P. Marks, P. Reynell,
Columbia University College of Physicians and Surgeons

The volume of blood held within the splanchnic vascular bed (SBV) may be measured indirectly in dogs and man by a "dilution" technique. Circulating splanchnic plasma volume and red cell mass may be determined simultaneously on the basis of the local dilution of I^{131} labeled human serum albumin and P^{32}-labeled red blood cells. The quantity of these substances dispersed within the splanchnic bed at equilibrium may be estimated from the difference between average concentrations in arterial and hepatic venous blood during equilibration following intravenous administration, multiplied by hepatic blood flow during the same period. This figure divided by the equilibrium concentration yields values for circulating splanchnic plasma volume and red cell mass, respectively. Calculation of mean circulation time indicates that red cells travel more rapidly than plasma through the splanchnic blood vessels. The estimated splanchnic hematocrit is significantly less than the total body hematocrit, suggesting that the SBV is distributed chiefly within the smaller vascular radicles. Changes in SBV during hemodynamic adjustments induced by hexamethonium bromide, hydrazine phthalazine, and hemorrhage indicate that the splanchnic bed participates actively in determining the distribution of blood in the body.

Relationship between Sensitivity to Alternating Electric Stimulation of the Eye (Phosphene Threshold) and State of Adaptation

Johannes Clausen, *Columbia University*

Thresholds of visual sensation (peripheral phosphenes), (in response to sine-wave electric stimulation in the frequency range of 6 to 70 cy/sec), were recorded while the eyes of the subjects were adapted to brightness levels of 0.032, 0.32, 3.2, 32, and 320 ml as well as to total darkness.

When the group averages based on seven observers were plotted as intensity-frequency curves for each state of adaptation, it was found that an increase in the adapting intensity increased the threshold at low frequencies, whereas it lowered the threshold at high frequencies. In other words, the intensity-frequency curves all cross one another over a relatively wide range of frequencies, so that at high frequencies a complete reversal of order is found as compared with the order at the lowest frequencies.

These results are in accord with data on direct electric sine-wave stimulation of nerve fibers, if it be assumed that adaptation to increasingly higher luminance results in increased electric excitability and in faster accommodation of the stimulated nerve fibers.

Nature of Bacitracin

Lyman C. Craig, W. Hausmann, J. R. Weisiger,
Rockefeller Institute for Medical Research

A little more than 10 years ago Johnson and Melaney noted the antibiotic effect of debrided tissue from the infected wound of a little girl named Tracy. Further study showed the active principle to be elaborated by a variant of *B. licheniformis.* The antibiotic was called bacitracin.

Countercurrent distribution studies at the Rockefeller Institute indicated bacitracin to be a mixture of several unusual polypeptides now called bacitracin A, B, C, and so forth. A, the one present in largest amount, has been shown to contain 12 amino-acid residues. The amino-acid residue formula is Phe · Leu · (Ileu)$_3$ · Cys · Orn · Lys · His · (Asp)$_2$ · Glu. Hydrolytic studies have further revealed the probable amino-acid sequence and the presence of several linkages involving the amino-acid residues that are unique in peptide chemistry. The antibiotic action therefore appears to stem from the unusual way the residues are joined rather than from the presence of a distinctive so-called "prosthetic" group.

Origin of Symptoms in Wilt Diseases of Plants

A. E. Dimond, Paul E. Waggoner, David Davis,
Connecticut Agricultural Experiment Station

Vascular wilt diseases display two conspicuous symptoms: discoloration of vascular bundles and wilting. The relationship between them has not been clear. Our data on *Fusarium* wilt of tomato suggest that vascular discoloration arises by a three-stage process. (i) Fungal pectin esterase and polygalacturonase hydrolyze the pectins cementing the host cells together, thus disorganizing them. (ii) Disorganized host cells are attacked by glucosidases that split polyphenols from phenolic glycosides. (iii) The polyphenols are oxidized to the discoloring melanoid pigments by terminal oxidases of the host. The pectic enzymes and the glucosidase can be found in *Fusarium* cultures and in the tracheal sap of diseased, but not of healthy, plants. A glucosidase alone, emulsin, causes no discoloration of tomato stems. Emulsin plus macerated cells discolor stems more than macerates alone. Polyphenols such as pyrogallol reproduce in tomato stems the vascular discoloration characteristic of tomato wilt.

Water moves as rapidly through pyrogallol discolored stems as through normal ones. In diseased stems, however, water moves at about 2 percent of the rate in healthy ones. Impeded water movement causes wilting and apparently results from plugs in stems and petioles, observable in fresh, but not in fixed, sections. Partial hydrolysis of host pectins by fungal enzymes or the resynthesis of hydrolytic products to gums seems likely to cause the plugs that impede water flow. Vascular discoloration is thus related to, but is not the cause of, decreased water flow.

Prediction of the Ionic Character of Chemical Bonds

B. P. Dailey, *Columbia University*

In theoretical chemistry, the reactivity and properties of a molecule are frequently discussed in terms of the ionic character of its chemical bonds. It has been suggested that this property of a chemical bond is related to the difference in electronegativity of the two atoms forming the bond.

The relationship recently obtained between the electronegativity difference of the two bonded atoms as a singly bonded diatomic molecule and the ionic character of the bond are discussed. This relationship is based primarily on the wide variety of nuclear quadrupole coupling constants derived from the data of microwave spectroscopy. Additional recent dipole moment data were also used to establish and verify this relationship. One of the points established by this approach is that bonds between atoms that differ in electronegativity by more than 2 units are almost completely ionic.

Unfortunately, it has not been possible previously to extend a relationship similar to the afore-mentioned one to chemical bonds in polyatomic molecules. The electronegativity of an atom changes when the atom forms more than one bond, and this change cannot be simply calculated. It has recently proved feasible to derive a table of the electron withdrawal power or electronegativity of functional groups such as SO_4 and OH from a study of so-called "chemical shifts" in the high-resolution nuclear magnetic resonance spectra of compounds containing these functional groups.

In particular the relative electronegativities of the functional groups have been derived from the shift in the value of the resonant magnetic field for protons in the methylene and methyl groups in molecules of the type C_2H_5X, where X is the functional group. The position of the methyl resonance was used as a fixed internal standard. The relationship between the chemical shifts and electronegativity was established using $H(C_2H_6)$ and Cl (C_2H_5Cl) as reference points.

Some Interesting Properties of the Enzyme Ascorbic Acid Oxidase

Charles R. Dawson, *Columbia University*

The experimental realization that trace amounts of certain metallic elements play fundamental roles in the life-processes of plants and animals has stimulated much interest in recent years. One result of this new interest has been a focusing of attention on the catalytic chemical processes of the living cell. Many of the catalytic agents of the cell, the enzymes, have been isolated and carefully examined for their metal content or metal requirements during function. Several enzymes, containing the metallic element copper as a vital feature of their protein structure and their function, have been found and investigated. In this group of copper-proteins, the enzyme that catalyzes the direct aerobic oxidation of vitamin C, ascorbic acid oxidase, has been found to have most interesting properties in regard to its structure, color, catalytic function, and stability. New information concerning these features of the enzyme has been obtained from studies involving exchange reactions with radioactive copper.

Role of the Spinal Cord in the Induction and Structuring of the Vertebral Column

S. R. Detwiler, *Columbia University College of Physicians and Surgeons*

Howard Holtzer, *University of Pennsylvania*

Various surgical procedures upon the developing urodele embryo (Amblystoma) have shown a remarkable influence of the spinal cord upon the development and differentiation of the vertebral column (Holtzer and Detwiler, 1953, 1954). In the absence of the spinal cord, the mesodermic somites fail to differentiate chondroblasts, and vertebrae are entirely lacking.

When a supernumerary piece of embryonic spinal cord is grafted into the ventrolateral region of the mesodermic somites, the cells normally destined to differentiate into trunk musculature, transform into cartilage, and the grafted cord becomes girdled by a supernumerary axial skeleton. This induced system is histologically and morphologically identical to a normal axial system. The notochord plays no formative role in this process.

Excision of the medial portions of the mesodermic somites (presumptive sclerotome) is followed by the differentiation of normal neural cartilaginous arches that have become chondrified from presumptive muscle tissue under the inductive influence of the spinal cord.

The interpolation of somites between two halves of a longitudinally split spinal cord is followed by the differentiation of a pronounced band of muscle fibers. In addition, each of the two miniature spinal cords may become girdled by skeletogeneous material. These and other findings attest to a definite formative role of the embryonic spinal cord upon the terminal differentiation of the somites.

The essential findings in the urodele have been confirmed by grafting experiments upon chick embryos (Fowler and Waterson, 1953) and by experiments dealing with the differentiation of mouse somites *in vitro* (Holtzer and Grobstein, in press).

Studies on the Physical Chemistry of Imidazoles

John T. Edsall, Yasuhiko Nozaki, Frank R. N. Gurd, David Garfinkel, *Harvard University*

Because of the importance of the imidazole group of histidine in the reactions of proteins, studies have been carried out on the Raman spectra of imidazole and 4-methyl imidazole and their hydrochlorides and on the binding of those imidazoles by the ions of zinc and cupric copper at different temperatures. Binding studies on imidazole itself have already been reported [J. T. Edsall *et al., J. Am. Chem. Soc.* 76, 3054 (1954)]. The 4-methyl imidazole shows affinities for the ions of copper and zinc very similar to those of imidazole itself. In all cases, it is found that 4 molecules of imidazole can be bound by either the copper or the zinc ion. The positive interactions between the successive binding constants are even more marked in 4-methyl imidazole than in imidazole itself. The first and last of the logarithmic intrinsic association constants for 4-methyl imidazole are (i) for copper at 29°, $\log \kappa_1 = 3.46$, $\log \kappa_4 = 2.48$; (ii) for zinc at 27°, $\log \kappa_1 = 1.85$, $\log \kappa_4 = 2.96$. Values for the intermediate binding constants will be presented later. All these association constants increase with decreasing temperature.

Raman spectra of the basic imidazoles and of their conjugate acids show far-reaching alterations in the spectrum associated with proton binding. These alterations presumably reflect changes in the character of the C—C and C—N bonds in the ring resulting from the acquisition of a positive charge on one of the ring nitrogens. Analogous studies, now being carried out on histidine derivatives, should furnish a basis for the spectroscopic detection of the ionization of imidazole groups in proteins.

Complex Ions and Electron Exchange

R. W. Dodson, *Columbia University* and *Brookhaven National Laboratory*

Some results of a continuing investigation of the kinetics of electron-exchange reactions between different oxidation states of elements in aqueous solution are presented.

These reactions, like many nonequilibrium oxidation processes, are markedly affected by anions capable of forming complexes with the reactants. In most of the known cases the electron exchange is accelerated. In some cases, however, a strong inhibition is observed. It proves convenient to relate the kinetic effects to the equilibriums of complex formation.

The 2-electron transfer between thallous and thallic ions has been studied from this point of view in the presence of chloride and of cyanide. The 1-electron transfer between ferrous and ferric ions has been investigated in the presence of thiocyanate, bromide, and oxalate. The results are compared with earlier work on the thallium, iron, and other exchange systems, and, to the extent possible, with existing theory on the rates of electron transfer. Some rather striking relationships between the heats and entropies of activation in the different systems are found.

Work was performed with the support of the U.S. Atomic Energy Commission.

New Antimetabolic Compounds

Morris Engelman, Horace B. Gillespie, Kathe B. Liedke, Samuel Graff, *Columbia University College of Physicians and Surgeons* and *Francis Delafield Hospital*

The synthesis of new benzimidazoles and benzotriazoles recently reported has been extended to include related quinoxaline and other derivatives. The structures are somewhat analogous to those of the purines and of 8-azaguanine, a carcinostatic agent. There is only presumptive evidence, however, that these compounds inhibit nucleic-acid metabolism. They appear not to interfere with respiration. The compounds exhibit antimetabolic activity on developing frog embryos. Amphibian embryos provide certain advantages for the study of antimetabolic activity, since they constitute closed systems that do not require nutriments from without. The embryos exhibit selective responses to the compounds according to developmental stage. Among the newer compounds 5-nitro-7-methoxy quinoxaline is perhaps significant, because it inhibits differentiation, rather than cell division, in *Rana pipiens*. The synthesis and biological effects of these compounds are discussed.

Application of Paramagnetic Resonance Spectroscopy to Chemical Problems

George K. Fraenkel, *Columbia University*

The new technique of paramagnetic resonance absorption spectroscopy has recently been employed to detect minute amounts of molecules which contain essentially free electron spins. An instrument has been developed that is capable of detecting about 2×10^{-11} moles of a representative organic compound containing one unpaired electron per molecule; we estimate that, under appropriate yet typical conditions, 5×10^{-14} moles should be detectable.

The properties of the biologically important semiquinones have been studied, and the paramagnetic spectrum of the unstable p-benzosemiquinone gives the first direct evidence for the existence of this radical in solution. Spectra of other more stable semiquinones have been observed, and structure is found in these spectra that is believed to result from interaction between the electron spin and the protons in the radicals; it is useful for identifying the radical species and for determining the location of an unpaired electron in a molecule.

Radicals have also been detected for the first time in quenched, and partially polymerized, vinyl polymers; a distinctive spectra is obtained that is related to the nature of the monomer used. Molten sulfur, well known to possess a transition region of high viscosity, has been shown to contain radicals, thus confirming the hypothesis that chain polymers are formed at the transition temperature. The strength of the sulfur-sulfur bond in a chain can be derived from measurements of the intensity of the paramagnetism. The excited state of certain types of thermochromic compounds has been shown to be paramagnetic, and the equilibrium constant for the transformation from the ground to the excited state can be evaluated.

Conductance of Strong Electrolytes at Finite Dilution

Raymond M. Fuoss and Lars Onsager, *Yale University*

Previous work on strong electrolytes, which considered the long-range effects of electrostatic forces proportional to the first power of the ionic charges, shows that the equivalent conductance of strong electrolytes approaches linearity in the square root of concentration c as the dilution approaches infinity. The experimentally observed conductance curves approach the limiting tangent from above; we (1932) attributed these positive deviations to indirect effects proportional to higher powers of the charges than the first. Our present computation includes terms that involve the squares of the charges.

An explicit conductance equation for electrolytes containing two species of ions results, when the improved relaxation equation is combined with the electrophoresis term given by Onsager and Fuoss. It describes the approach of the conductance curve to the limiting Debye-Hückel-Onsager tangent. The limiting behavior of the transcendental terms in the equation is like that of $c \log c$, but in the practical working range explicit functions of the form e^{x} Ei (x) must be used. The equation (which contains only two arbitrary parameters, limiting conductance and mean ionic radius) precisely reproduces Shedlovsky's conductance data for lithium, sodium, and potassium chlorides in water at 25°C up to at least 0.1 normal. Deviations between theoretical and observed curves for potassium and silver nitrate solutions clearly show that ion pair formation occurs in these salts. In addition to providing a theoretical treatment of strong (that is, unassociated) electrolytes at nonzero concentrations, the equation also provides an unambiguous criterion for establishing the occurrence of ion pair formation and should permit a much more realistic computation of association constants than has hitherto been possible.

Radiochemical Studies of Nuclear Reactions at Bev Energies

Gerhart Friedlander, *Brookhaven National Laboratory*

Determinations of the yields of radioactive end-products have been used for the study of interactions of complex nuclei with protons of 0.4 to 3.0 Bev kinetic energy. In the bombardment of both copper and lead targets with 2.2 Bev protons, products with 20 or more mass numbers below the target mass are formed with much higher cross sections than in similar bombardments with 300 to 400 Mev protons.

In the case of lead targets, even such low-mass nuclides F^{18}, Na^{24}, Mg^{28}, P^{32} are formed with cross sections of the order of 1 millibarn. In the yield-versus-mass curve of the products from lead bombardments, there is no pronounced peak that can be clearly associated with fission into two almost equal fragments. Measurements on recoil energies of certain products such as barium isotopes also show that these are not formed by a fission process as they are at lower bombarding energies. The excitation functions for a number of reactions such as the formation of the low-mass products from lead rise steeply with proton energy above about 0.5 Bev, whereas the cross sections for relatively simple reactions in heavy elements decrease with increasing proton energies.

The results may be interpreted to indicate that very large energy transfers (upward of hundreds of Mev) to the struck nuclei are quite probable with bombarding energies in the Bev region. Some characteristic reactions, particularly the formation of some alpha-emitting rare-earth activities in heavy element targets, are useful as monitors for high-energy beams.

Research was performed under the auspices of the U.S. Atomic Energy Commission.

Numerology of Polypeptide Chains

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N. Metropolis, *Los Alamos Scientific Laboratory*

It seems very likely that the specificity of proteins is determined by the particular order of amino acids in long polypeptide chains. It has been suggested that this sequence in its turn reflects the order of purine and pyrimidine bases in the long polynucleotide chains of DNA or RNA. If this is true, there must exist a unique coding procedure that permits one to translate long sequences formed by four different elements (bases) into equally long sequences formed by about 20 different elements (amino acids). Since the number of all possible sequences of the second kind exceeds by a very large factor the corresponding number for the sequences of the first kind, the code in question must be extremely restrictive and must lead to strong intersymbol correlation between the neighboring amino acids in known protein sequences.

One way to compare different possible codes proposed so far is to study statistically the dependence between the frequency of occurrence of different amino acids and the number of different neighbors that they possess in natural sequences and in the artificial sequences built up according to various proposed coding procedures. This is done by using the so-called Monte Carlo method on the Los Alamos electronic computer (Maniac) in which a large number of random sequences formed by four different elements are translated according to the various coding procedures into corresponding sequences of 20 different elements and the results are analyzed statistically. Observed and artificially constructed sequences are compared by means of graphs.

Behavior of Neutral Fields under Charge Conjugation

M. Gell-Mann, *Columbia University* and *University of Chicago*

A. Pais, *Institute for Advanced Study*

Certain familiar neutral particles, like the photon and π^0-meson, have the property that the operation of charge conjugation turns them into themselves. Other neutral particles, like the neutron, are supposed to behave differently; charge conjugation is supposed to transform the neutron N and antineutron $\overline{N}$ into each other, while the process $N \longleftrightarrow \overline{N}$ is to be rigorously forbidden by the law of conservation of heavy particles.

A third type of behavior is possible, in principle, for neutral fields, whether bosons or fermions. The particle p and its charge conjugate $\overline{p}$ may be distinct, but with the process $p \longleftrightarrow \overline{p}$ merely weak rather than rigorously forbidden. Under these circumstances, it is useful to consider a change of representation. If p is represented by a field χ and $\overline{p}$ by the charge conjugate field $\overline{\chi}$, one may introduce the fields $\chi_1 = \frac{\chi + \overline{\chi}}{\sqrt{2}}$ and $\chi_2 = \frac{\chi - \overline{\chi}}{\sqrt{2}_i}$ and corresponding "particles" p_1 and p_2.

Now it has been suggested (*1–3*) that the θ^{-o}-meson, a neutral boson, may belong to the third class, and furthermore that as far as production mechanisms are concerned, θ^{-o} and $\overline{\theta}^{-o}$ behave quite differently. In the decay of these particles, however, it would be θ_1^{o} and θ_2^{o} that have different characteristics. In fact, if one of these latter can decay into 2 pions then the other cannot. Some consequences of this situation are discussed.

It is conceivable that the neutrino also belongs to the third class. Some arguments relevant to this question are given.

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Luminosity Curves for Normal and Dichromatic Subjects Including a Case of Unilateral Color Blindness

C. H. Graham and Yun Hsia, *Columbia University*

During the recent past we have studied the luminosity functions of three groups of subjects, made up, respectively, of: (i) seven normal individuals, (ii) five protanopes (red-blind persons), and (iii) five deuteranopes (green-blind individuals).

In normal subjects, the luminosity curves for cone threshold show a maximum near 550 mμ, and "humps" appear in the red and the blue. These findings are in line with some results obtained by other investigators.

The data on the protanopes show the expected lowering of luminosity on the long wavelength end of the spectrum. As a result, the hump at 610 mμ is practically obliterated. Throughout the rest of the spectral range the sensitivity of the protanope is about the same as that for the normal.

In the case of the deuteranopes, it can be shown that the luminosity curve exhibits reduced sensitivities in the wavelength range between 530 mμ and 415 mμ.

A young woman gave typically deuteranopic discriminations with her left eye on our tests and normal discriminations with her right eye. The luminosity curves obtained on the two eyes differ in absolute sensitivity values in the blue and green regions of the spectrum; the sensitivity of the normal eye in these regions is considerably greater than the sensitivity of the deuteranopic eye. In the red end of the spectrum both eyes have the same sensitivity. The data on this subject are in line with the group results: deuteranopes show a loss of sensitivity in the green and blue as contrasted with normal individuals.

The relationship of the findings to the character of fundamental response curves is considered. The research was supported by a contract between the Office of Naval Research and Columbia University.

Molecular Microwave Oscillator and High-Resolution Spectrometer

J. P. Gordon, T. C. Wang, H. J. Zeiger, C. H. Townes, *Columbia University*

An experimental device has been developed that can be used as a very high resolution microwave spectrometer, a microwave amplifier, or a very stable oscillator. It utilizes a beam of molecules, electrostatic focusing of certain states of these molecules, and a cavity in which radiation can occur and be detected. As a spectrometer, the device allows considerable reduction in Doppler width and has made visible new hyperfine structure in the spectrum of NH_3, which is discussed.

The apparatus involves amplification of microwaves as a result of interaction between radiation and the beam of molecules. As an amplifier, it has a very narrow band width and can give a particularly low noise figure. Sustained oscillations, powered by induced emission from the molecules, may be produced when the beam of molecules is sufficiently intense. The behavior of such an oscillator and its possible use as a frequency standard are discussed.

Intermolecular Forces and Induced Infrared Absorption

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The intrinsic spectral absorbances of molecular vibrations are modified by intermolecular perturbations when the molecules enter into condensed phases. The induced absorbance can be observed separately for each different mode of vibration to provide a substantial fund of information concerning molecular interactions involving a single molecular species. This information can be presented, item by item, in terms of an induced motion superimposed upon the intrinsic molecular one and thereby can be related in principle, through Newtonian laws of motion, to intermolecular forces. A single molecular species will yield a multiplicity of such relationships, the ultimate number being limited only by the number of its modes of vibration (including combinations and overtones as well as fundamentals) that can be excited spectroscopically.

The program of investigations is still in its preliminary stages, but findings to date are summarized for several systems including, among others, liquid and solid benzene, solid naphthalene, and a number of binary liquid solutions. Some tentative, qualitative generalizations are indicated.

Spatial Summation of Inhibitory Influences in the Eye of *Limulus*

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The discharge of impulses in a single optic nerve fiber from the eye of *Limulus,* in response to illumination of the receptor element from which it arises, is slowed by illuminating receptors in nearby regions of the eye. This inhibition is greater the higher the intensity of illumination on the nearby region and the closer this region is to the receptor under observation. It is also greater the larger the area illuminated; spatial summation of inhibitory influences thus occurs in this eye. This summation presumably takes place over the plexus of nerve fibers that underlies the receptors.

The receptors that inhibit an active receptor element in their vicinity are themselves subject to mutual inhibitory interactions, which reduce the total effect that they exert. For example (i) two small areas of given inhibitory effectiveness may together produce a smaller summed effect when they are close to each other than when they are far enough apart to exert little inhibition upon each other; (ii) a region that is too far from the receptor under observation to exert a direct effect upon it may actually release it, partially, from the inhibition caused by a nearer region, by inhibiting the activity of receptors in that region. Thus the resultant inhibition of a receptor depends on the spatial distribution of light on receptors in regions of the eye surrounding it.

Similar interactions may be significant in visual systems of other animals and probably play an important role in the mechanism of visual contrast.

Studies on Animal Virus Reproduction

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Influenza A and B virus particles can be enumerated by determining the number of erythrocytes they cause to sediment at an increased rate. Because one infective particle can initiate reproduction in susceptible cells, the ratio of infective to total particles can be found by determining the smallest number of particles that can infect.

The number of cells lining the allantoic sac of the chick embryo has been shown to be 1.8×10^7. When less than one particle per cell of influenza A or B virus is inoculated, about 6×10^{10} new particles are produced. If all cells support virus reproduction, the yield per cell is approximately 3×10^3 particles.

With inocula of less than one particle per cell all the new particles of either virus are infective and the logarithmic rate of production is constant until the number of particles reaches about 90 per cell. Then the rate diminishes sharply with increasing time, and noninfective particles accumulate rapidly. The time to double the number of particles is 46 min with influenza A, 60 min with influenza B virus. Both viruses lose infectivity at a rapid rate. In allantoic fluid at 35°C the half-life of infective particles is 147 min for influenza A, 85 min for influenza B virus. Thus the ratios between generation time and half-life are as high as 0.31 and 0.71, respectively.

Infective or noninfective particles of either virus in amounts greater than two per cell alter the reproductive process in three ways: (i) The interval before new particles appear is increased. (ii) The logarithmic rate of production is decreased. (iii) The proportion of new particles that are infective is markedly diminished in direct relation to the initial particle-cell ratio.

In contrast, infective Newcastle disease virus has a half-life greater than 14 hr at 35°C and a generation time of 43 min. Thus the generation time-half-life ratio is less than 0.05. The yield per cell is about 1×10^3 particles. Unlike influenza, Newcastle disease virus in amounts greater than two particles per cell does not alter the reproductive process. Regardless of the particle-cell ratio, all new particles produced are infective.

Effect of Chemicals on Sporulation of Fungi

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The process of asexual sporulation in fungi is only vaguely understood. It necessitates cell division and a new cell wall that is distinct so that the spore can be pinched off. It requires extra energy above that needed for vegetation. Sporulation is induced by an optimum energy level that varies among fungi. Metals are known to augment sporulation. The following classes of compounds generally reduced sporulation of *Monilinia fructicola* in pure culture on agar: chelating reagents, ketones, thiones, amines, phenols, hydrocarbons, and chlorinated hydrocarbons. The effect of ketones and thiones is quenched by a basic nitrogen group nearby on the molecule, and vice versa. α, β-Unsaturation of a ketone usually enhances biological activity. Here it seems to quench activity.

We suggest that chelating agents bind metals that participate in energy-giving oxidative reactions, that ketones and thiones lift the redox potential above the optimum for sporulation and the amines push the potential below the optimum, that they cancel each other when present on the same molecule, that mitosis is discouraged (i) by reaction of the ketones, thiones, amines, and phenols with the proteins of the chromosomes, and (ii) by interference with spindle-fiber formation by hydrocarbons and chlorinated hydrocarbons. We suggest further that fission of bacteria and sporulation of fungi may be biochemically related, because metal starvation, phenols, and certain amino compounds are known to retard fission of certain bacteria.

Components of the Specific Polysaccharides of Types IX, XII, and XIV Pneumococcus

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Because numerous polyglucoses give precipitates in type IX and type XII antipneumococcus serums and several galactans precipitate type-XIV antiserum, it appeared desirable to investigate the sugars contained in the type-specific capsular antigens of types IX and XII pneumococcus and to learn more of the structure of type-XIV polysaccharide. The first two substances contained glucose, as might have been expected from the aforementioned cross reactivity. By paper chromatography glucuronic acid, glucosamine, and another basic sugar or disaccharide were also tentatively indicated in the type-IX substance, as well as ribose, probably due to accompanying nucleic acid. The infrared spectrum showed broad absorption around 850 cm^{-1}, indicating α-linkages. The type-XII polysaccharide contained glucose and galactose, as indicated chromatographically, with a smaller quantity of hexosamine, probably N-acetylated, since the infrared spectrum showed absorption peaks at 1644 and 1560 cm^{-1}.

The type-XIV substance, hitherto believed to contain only galactose and N-acetylglucosamine, both of which also occur in the cross-reacting blood group substances, was found to be more complex. Chromatographic and ionophoretic tests showed that glucose and glutamic acid appeared on vigorous hydrolysis. These were possibly derived from products with the mobilities of di- and oligosaccharides which were evident on milder hydrolysis. In the infrared spectrum absence of absorption around 840 cm^{-1} and the presence of a peak at 890 cm^{-1} indicated that the majority of the linkages were of the β-type.

Relationship of Wound Sap to the Formation of Crown-Gall Tumor Cells

Richard M. Klein, *New York Botanical Garden*

Tap roots of carrots differ in their ability to form crown-gall tumor cells independent of the strain of virulent crown-gall bacteria used in the quantitative assays. The tumorous alteration of the cells is a function of their cell and tissue type and of their position in the root. It is also affected by the juices expressed from the various tissue areas. This wound sap is involved in the activation or conditioning of normal plant cells and in the synthesis, by crown-gall bacteria, of a tumor-inducing principle that alters conditioned cells into incipient tumor cells. The bacterial synthesis of tumor-inducing principle has been demonstrated *in vitro*.

Venezuelan Guayana—a Long-Known but Little-Understood Region

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Belief by Spanish explorers and adventurers of the mid-16th century in the legend of the fabulous and gold-rich city of Manoa in the interior of Venezuelan Guiana led to a burst of interest in the region, culminating in Sir Walter Raleigh's ill-fated attempt to discover El Dorado. Major errors in the concept of the geography of the region at that time are briefly outlined. Not until Alexander von Humboldt's travels in the beginning of the 19th century was there a scientific evaluation of some of the geographic realities. During the past 20 years, the efforts of the Venezuelan Government and such individuals as the explorer, Felix Cardona, and the ornithologists, William H. Phelps and William H. Phelps, Jr., as well as the advent of air photography, have given an impetus to our understanding of the region, many parts of which still remain virtually unknown.

Cartographically it has been one of the most puzzling areas in South America. The American Geographical Society, in its program for preparing a uniform map of the Americas south of the Rio Grande on the scale of 1:1,000,000 was thrice forced to recompile Guiana before publishing because of new and conflicting information. It prepared a reconnaissance map of 16,000 mi^2 from air photographs in New York in connection with one of Phelps' ornithological expeditions, thus providing the map from which scientific exploration of the virtually unknown could be planned beforehand.

Of particular interest are those isolated mountains rising into the subtropical zone, for there extreme endemism is exhibited by both plants and birds. The nature and origin of the mountains, remnants of a once widespread sandstone formation, is discussed briefly.

Purification of Human Antidextran

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Antibody to dextran has been produced in human beings by the injection of small quantities of dextran. These antibodies, as formed in most individuals, have specific combining sites with dimensions complementary to terminal nonreducing chains averaging at least three and probably four $1 \rightarrow 6$ anhydroglucopyranose units.

Using dextran NRRL B512 containing 96 percent $1 \rightarrow 6$ and 4 percent $1 \rightarrow 3$ like units as established by periodate oxidation [J. C. Rankin and A. Jeanes, *J. Am. Chem. Soc.* 76, 4435 (1954)], the antidextran is precipitated and washed with saline to remove extraneous serum protein, the specific precipitate is suspended in acetate buffer at *p*H 5.1 and a small quantity of dextranase from *P. funiculosum* [kindly supplied by E. J. Hehre; see H. M. Tsuchiya *et al.*, *J. Bact.* 64, 513 (1952)] is added. On warming at 37°C for 1 hr the precipitate goes almost completely into solution as a consequence of the digestion of the dextran. The resulting oligosaccharides are dialyzed out, and a small amount of insoluble material is removed, giving the final antibody solution.

Antibody solutions contained about 90 to 95 percent of the nitrogen in the original specific precipitate, 80 to 90 per cent of which was reprecipitable by dextran. The human antidextran showed a single homogeneous boundary in the ultracentrifuge of sedimentation constant of about 7.0. Availability of purified antibody to an antigen composed of only a single sugar constituent together with the already described homologous oligosaccharides makes possible direct physiochemical measurements on the nature of oligosaccharide antibody complexes.

These studies were carried out under the William J. Matheson Commission and the Office of Naval Research [contract Nonr 266 (13)], Navy Department, Washington, D.C.

General Mechanisms for Enzyme Action

Daniel E. Koshland, Jr., *Brookhaven National Laboratory*

A wide variety of enzymatic reactions that perform diverse biological functions and present apparently dissimilar chemical reactions, nevertheless, conform to the stoichiometry $BX + Y \rightarrow BY + X$. Included in this group are the phosphatases, phosphorylases, esterases, lipases, proteases, glycosidases, branching enzymes, and so forth. It is postulated that this large group of enzymes acts catalytically through a few basic mechanisms. These have been named the single-displacement mechanism, the front-side-displacement mechanism, and the double-displacement mechanism. The first two of these require that both substrates be present simultaneously on the enzyme surface, whereas the latter allows a primary electron-sharing attack by the enzyme on one substrate (BX) even in the absence of the second substrate. The fundamental characteristic of all of these mechanisms is that they proceed by steps in which a single bond is broken as a single bond is formed in direct analogy to the well-known displacement mechanisms of organic chemistry.

With these assumptions it is possible to explain many observed phenomena such as the stereochemistry of the enzymatic reactions, the correlation of bond breaking with specificity, the occurrence or absence of exchange between BX and radioactive X, the simultaneous transferase and hydrolytic properties of some enzymes, and a rough explanation of the pH dependence of enzymatic activity. Specific illustrations have been obtained with 5′ nucleotidase, beta-glucosidase, acetylcholinesterase, invertase, the phosphorylases, and glutamine synthetase.

Research carried out under the auspices of the U.S. Atomic Energy Commission.

Measurement of Variability in Species of Fossil Invertebrates

John Imbrie, *Columbia University*

The coefficient of variation (V) has been widely employed as an objective measure of variability. If samples are reasonably homogeneous with respect to age, sex, environment, stratigraphic position, and locality, this procedure is normally justified. It frequently happens, however, that individuals in a collection of fossil invertebrates vary widely in age and that criterions are lacking to distinguish age groups. In these circumstances the form of the size-frequency distribution of any linear measurement is determined primarily by geologic factors extrinsic to the organisms, and V is unrelated to biological variability. This difficulty can be largely avoided by considering pairs of logically related linear measurements and defining variability in terms of the dispersion of values about the curve of relative growth calculated by standard regression methods.

Using the standard error of estimate as a measure of absolute dispersion, a coefficient of relative dispersion analogous to V can be obtained. The use of this measure has been justified empirically by Klauber on populations of modern rattlesnakes and by the present author on populations of modern and fossil brachiopods.

Velocity Distribution Measurements in Atomic and Molecular Beams

P. Kusch and R. C. Miller, *Columbia Unviersity*

A high-resolution spiral rotor velocity selector has been built for study of the velocity distribution of the particles in atomic and molecular beams. For atoms effluent from an oven with slits designed to approximate as nearly as possible an ideal aperture of infinitesimal thickness, it is found that the velocity distribution is that to be expected from a Maxwellian velocity distribution within the oven. In the case of the alkali halides the velocity distribution indicates the presence of polymers of the diatomic molecule. The polymers are principally dimers and are an important component of the lithium halides. They decrease in abundance, under our experimental conditions, with increasing atomic number of the alkali and are unobservable for the cesium halides. An observation of the abundance of the dimers as the temperature and pressure of the gas in the oven are varied yields the heat of dissociation of the dimeric molecule into two monomeric molecules.

Rate of Evaporation of Water through Monolayers of Fatty Acids

Victor K. LaMer and Robert J. Archer, *Columbia Unviersity*

The control of evaporation from reservoirs is a problem of economic importance. The influence of monolayers has been investigated by measuring the rate of absorption of water vapor by a desiccant surface 2 mm above the water surface. The rate of evaporation is reduced by a factor of 10^4 by these monolayers. The data are reported as specific resistances of the monolayers to evaporation for the saturated fatty acids, C_{17}, C_{18}, C_{19}, and C_{20}. They were measured as a function of surface pressure, chain length, monolayer phase, subphase composition, and temperature.

For a liquid condensed phase, the logarithm of the resistance of a monolayer is independent of the surface pressure and pH of the subphase but is a linear function of the chain length and the reciprocal of absolute temperature, which substantiates the description in terms of an exponential energy barrier.

A theory is proposed for the source of the energy barrier; calculation of its magnitude agrees well with known data on heats of vaporization. A full discussion will appear in the *Journal of Physical Chemistry.*

Temporal and Intensity Limits of the Flicker-Fusion Threshold

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When the eye is stimulated by intermittent light, any of several sensory experiences may result. The experience of flicker may change to fusion, or vice versa; that is, a critical flicker-fusion threshold (CFF) may be established. The basic considerations are successive pulses of light having measurable duration; the pulses are separated by measurable intervals of reduced light or absence of light. In most experiments the duration of the light pulse and darker interval bear some regular relationship to each other, which usually has been expressed as a light-dark ratio. It is of interest to consider the boundaries in time and luminance within which the CFF has been found to occur. The luminance limits are approximately -6.67 log millilamberts to 5.5 log millilamberts. The pulse duration limits extend from 8×10^{-3} to 2.5×10^5 μ sec. The darker interval duration limits extend from 0.6 to 2.5×10^5 μ sec. A three-dimensional graphic representaion of these boundaries which gives rise to a "solid" is shown. Within these boundaries the interaction of the effects of the ten or more known determinants of the CFF may be systematically located and their effect on the temporal and luminance components may be apportioned.

Model for Multiple Meson Production

T. D. Lee, *Columbia University*

A Bloch-Nordsieck type treatment of multiple meson production is presented. In this treatment the physical nucleon is regarded as a composite system composed of a core surrounded by a meson cloud. The collision of two nucleons is assumed to consist of a sudden exchange of spin, isotopic spin, and momentum between the cores of these two nucleons; these, in turn, shake off part of the surrounding mesons as radiation. This treatment is applied to both the symmetrical scalar meson theory and the neutral pseudoscalar theory for arbitrary values of the coupling constant.

Uranium-Lead Method of Age Determination

J. Laurence Kulp, ***Columbia Unviersity***

The absolute geologic time scale has been inferred from age measurements by the uranium-lead method. New investigations have elucidated the factors that produce anomalies among the various isotopic ratios that are used for the age measurement in this method, that is

$$\frac{\mathrm{Pb}^{206}}{\mathrm{U}^{238}},\ \frac{\mathrm{Pb}^{206}}{\mathrm{Pb}^{210}},\ \frac{\mathrm{Pb}^{207}}{\mathrm{U}^{235}},\ \frac{\mathrm{Pb}^{207}}{\mathrm{Pb}^{206}},\ \text{and}\ \frac{\mathrm{Pb}^{208}}{\mathrm{Th}^{232}}.$$

Correction for common lead contamination is improved if the isotopic composition of the common lead of a district is known. Radon leakage occurs in all radioactive minerals, but this phenomenon can be measured and its effect calculated. Leaching of lead in preference to uranium also appears to occur under certain conditions. The agreement in the isotopic and chemical assays from various laboratories suggests that the analytic procedures are not a significant source of error.

An attempt is made to illustrate each of these effects with new data, to show which age determinations can be accepted with a high degree of confidence, and to propose the experimental program required to fill out the geologic calendar.

Alternate Modes of Pion and Muon Decay and of Muon Capture

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Columbia University

We have searched for the following three processes:

1) $\pi^+ \rightarrow e^+ + \nu$
2) $\mu^+ \rightarrow e^+ + \gamma$
3) $\mu^- + \mathrm{Cd} \rightarrow \mathrm{Cd}^* + e^-$

The apparatus employed electronic counting techniques and was of considerably greater sensitivity than has previously been used for this purpose. Nevertheless, we have found no evidence for the existence of these reactions and find

1) Rate $(\pi^+ \rightarrow e^+ + \nu)/\text{rate}\ (\pi^+ \rightarrow \mu^+ + \nu) < 5 \times 10^{-5}$
2) Rate $(\mu^+ \rightarrow e^+ + \gamma)/\text{rate}\ (\mu^+ \rightarrow e^+ + 2\nu) < 2 \times 10^{-5}$
3) Rate $(\mu^- + \mathrm{Cd} \rightarrow \mathrm{Cd}^* + e^-)/\text{rate}\ (\mu^- + \mathrm{Cd} \rightarrow \mathrm{Ag}^* + \nu) < 3 \times 10^{-3}$.

Present theory does not seem to provide an understanding of the smallness of these interactions compared with those that are actually observed.

Cytochemistry of the Human Ovary

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Ovarian histophysiological studies have long centered their interest on the identification of the cells that secrete ovarian hormones or related substances. Most of the enlightenment on this subject has been obtained from studies of animal ovaries. This paper presents a cytochemical analysis of preovulatory follicles in sections of resected human ovaries.

Since ovarian hormones are fat-soluble steroids, lipid tests were correlated to identify the types of lipid and their distribution throughout normal follicular development and atresia. Reactive lipid substances, mainly cholesterol, were visualized in theca interna cells of healthy preovulatory follicles. The granulosa of normal follicles contained no lipid. Nonspecific lipid was first localized in theca cells of preantrum-stage follicles; cholesterol in the succeeding early antrum stage. Granulosa lipid, acidic or phospholipid in nature, appeared in atretic follicles of all types. The theca interna then, presumably, is the site of the production of ovarian hormones or of precursor substances.

Using the PAS technique, glycoprotein was inferred as a component of the follicular fluid, the zona pellucida, and the basement membrane. The zona pellucida was thus demonstrated as a thin membrane in the primary follicle. The earliest manifestation of the secretion of follicular fluid was in the four-layered follicle.

Vitamin B_{12}, Rhizobia, and Leguminous Plants

Alfred P. Levin, Helen B. Funk, Moses D. Tendler,
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Assays of *in vitro* cultures of root-nodule bacteria with *Euglena gracilis* var. *bacillaris* and with *Ochromonas malhamensis* confirmed that *Rhizobium meliloti, R. trifolii,* and *R. leguminosarum* synthesize vitamin B_{12}, as had been shown previously. Additional studies showed that the ratio of the amount of the vitamin excreted to that retained with the cells of *R. meliloti* was at least 1:2; of *R. trifolii,* at least 3:1; and of *R. leguminosarum,* at least 1:1.

Assays of the pink (leghemoglobin-bearing) root nodules of alfalfa, clover, and pea plants revealed the concentration of vitamin B_{12} to be 3 to 34 times greater than that in the root tissues. In the case of alfalfa, the concentration of the vitamin in pink nodules was 400 percent greater than in white nodules.

Rhizobia isolated from pink nodules gave a different ratio of vitamin excreted to retained as compared with those for the bacterial cells grown *in vitro.* The *in vivo* ratios were for *R. meliloti,* 14:1, and for *R. trifolii,* 5:1. There was also an increase in the number of molecules of vitamin B_{12} synthesized per bacterial cell in the nodules, this being especially marked for *R. trifolii.*

Botanical Exploration of the Guyana Highland

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For 250 years naturalists have been lured to the Guyana Highland of northeastern South America by the great riches of plant and animal life that are to be found there. The sandstone table mountains that form the characteristic topographic feature of the region bear on their summits a flora that contains the highest incidence of endemism known from any part of the globe of like area. The Guyana Highland extends from near the Colombian boundary across southern Venezuela and British Guiana to Surinam.

The New York Botanical Garden has been actively exploring this region since 1944. Sixteen expeditions have been made by the Garden thus far, with four more now in progress. Some 18,000 numbers of plant collections have been made in sets of 6 to 10 each and by the end of the current season, which draws this exploratory phase of the Garden's work in the Guyana Highland to a close, aproximately 150,000 specimens will have been taken. It is estimated that the area in all contains some 4000 to 5000 endemic species and 100 new genera, large numbers of which are as yet undescribed.

Effect of Some Iron Complexes on Hydrogenase

Alvin Krasna and David Rittenberg,
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We have previously shown that the enzyme hydrogenase is inhibited by very low concentrations of nitric oxide [*Proc. Natl. Acad. Sci.* 40, 225 (1954)]. In a search for other inhibitors, we have tested the effect of nitroprusside and several other pentacyano and hexacyano iron complexes on the hydrogenase of *Proteus vulgaris.* The enzyme activity was measured by determining its catalytic effect on the rate either of the orthopara hydrogen conversion or of the exchange reaction between HDO and H_2 [*J. Am. Chem. Soc.* 76, 3015 (1954)]. The following ions at a concentration of 10^{-3} molar had no inhibitory effect; ferrous, ferric, ferricyanide and ferrocyanide. Six pentacyano iron compounds, tested at 10^{-3} molar concentration inhibited hydrogenase about 50 percent. In a particular compound, nitroprusside inhibits 69 percent at $10^{-4}M$, 56 percent at $10^{-3}M$, and 46 percent at $10^{-2}M$.

During the experiments in which nitroprusside was tested for its inhibitory effect, it was observed that the solution of nitroprusside changed from its original faint orange to blue-green and finally to a yellowish-brown. Quantitative determinations show that 1 mole of hydrogen was consumed per mole of nitroprusside.

The blue compound formed after partial reduction is bleached by air to yield a compound other than nitroprusside. Nitroprusside is not reduced by hydrogen activated by platinum.

Interaction of High-Energy Nucleons with Complex Nuclei

J. M. Miller, *Columbia University*

The cross sections for the formation of various radioactive products that result from the inelastic interaction of protons in the 0.2- to 3-Bev energy range with complex nuclei indicate that, although the mechanism of compound nucleus formation advanced by Bohr (*1*) in the discussion of nuclear reactions induced by low-energy particles (below 50 Mev) certainly does not apply, nevertheless, at least part of the energy transferred during an inelastic collision in the higher energy range is statistically distributed among the nucleons in the nucleus: the observed distribution of products may be considered as the result of the "evaporation" (*2*) of particles from excited nuclei. This idea is useful for the estimation of the unmeasured cross sections for the formation of stable products.

If it is assumed that essentially all the nucleons lost from a struck nucleus are emitted by the "evaporation" mechanism, then the probability that a given quantity of energy is transferred during an inelastic interaction may be estimated from the experimental data (*3*). The application of this rather extreme assumption to the interpretation of some experiments carried out with protons in the Bev energy range yields internally consistent results for the probability function. This excitation-energy distribution function, in turn, is related to the problem of the interaction of high-energy nucleons with nucleons bound in the target nucleus.

The nonvanishing probability for rather large energy transfers calculated under this assumption from the results with Bev protons is qualitatively consistent with the observed increase in the free-nucleon interaction cross section in the Bev region over that in the 0.5 Bev region, and with the relatively copious meson production at the higher energy (*4*).

This work was partially supported by the U.S. Atomic Energy Commission.

References and notes: (1) N. Bohr, *Nature* **137**, 344 (1936). (2) V. F. Weisskopf, *Phys. Rev.* **52**, 295 (1937). (3) K. J. LeCouteur, *Proc. Phys. Soc.* **A65**, 718 (1952). (4) A. M. Shapiro, C. P. Leavitt, and F. F. Chen, personal communication.

Changes in Three-Dimensional Shapes of Cells, within the Apical Meristem, during Cell Division

Edwin B. Matzke, *Columbia University*

Cells in tissues have some features in common with the units of certain inorganic systems; they differ, however, in their origin from preexisting cells. In the present study, 400 interphase cells and 400 dividing cells were investigated. Median sections of the stem tip of *Anacharis densa* cut at 40 μ and stained in Feulgen and ruthenium red were used, and the cells were examined, in toto, under oil immersion.

The 400 interphase cells had an average of 13.9 ± 0.1 faces, the range being from 9 to 21. There were 101 cells with 14 faces; 13- and 15-faceted cells were also abundant. Hexagonal, pentagonal, and quadrilateral faces were most frequent. These 400 cells occurred in 96 combinations of faces; 38 cells had 4 quadrilateral, 4 pentagonal, and 6 hexagonal faces—the commonest combination—while four had 6 quadrilateral and 8 hexagonal faces, as in Kelvin's tetrakaidecahedra.

The 400 dividing cells averaged 16.8 ± 0.1 faces, the range extending from 13 to 22. In these cells there were 170 combinations of faces, and pentagonal faces were the most numerous. Cells in early prophase had an average of 16.4 ± 0.2 faces; in late prophase, of 16.7 ± 0.3 faces: in metaphase, of 16.8 ± 0.2; in anaphase, of 16.7 ± 0.3; in late telophase, of 17.1 ± 0.1 faces. In 150 daughter cells the number of contacts decreased to 12.6 ± 0.1.

It may be concluded that cells in interphase within the apical meristem have an average of close to 14 faces, that either prior to or in early prophase this average increases decidedly, that it continues to rise slightly during subsequent stages of division, and that new daughter cells average between 12 and 13 faces. The number of combinations of faces in both interphase and dividing cells is large, and no one configurational type predominates.

Studies on Ground Substances of Connective Tissue

Karl Meyer, Eugene A. Davidson, Alfred Linker,
Philip Hoffman, *Columbia University College of Physicians and Surgeons* and *Presbyterian Hospital*

Acid mucopolysaccharides occur in mammalian connective tissues in complex and typical patterns. Two of these polysaccharides are nonsulfated: hyaluronic acid and the recently isolated chondroitin. Four mucopolysaccharides are sulfated: chondroitin sulfate A, B, and C and the recently described kerato-sulfate. Hyaluronic acid and chondroitin, aside from the nature of the hexosamines, probably have very similar structures. Both form highly viscous solutions, the hexosaminidic bonds of both are hydrolyzed by testicular and bacterial hyaluronidases at comparable rates, and bacterial hyaluronidases yield from both polysaccharides hitherto unknown uronides unsaturated in the 4–5 position.

The deacetylated repeating disaccharide of chondroitin was isolated and crystallized. Its infrared spectrum was identical with that of chondrosine isolated from chondroitin sulfate A of cartilage and of C from umbilical cord. Chondroitin presumably is one of the sulfate acceptors of connective tissues. Studies on chondroitin sulfate B, obtained from skin, heart valves, tendon, and large blood vessels, have shown it to be markedly different from chondroitin sulfate A or C. B has a lower solubility and higher rotation than either A or C and is resistant to testicular hyaluronidase. It is hydrolyzed by acid at a rate markedly faster than A or C. It yields on decarboxylation 1 mole of CO_2 per hexosamine unit, whereas the carbazole reaction for uronic acid, which is normal for A or C, gives only half of the expected value. It yields a disaccharide with an infrared spectrum different from that of chondrosin. The neutral methyl esters of the sulfated polysaccharides have been prepared and structural studies including the reductive elimination of the sulfate groups for purposes of identification of its position are in progress.

Model Seismology Studies

Frank Press, Jack Oliver, Maurice Ewing,
Columbia University

Many problems in various branches of seismology may be investigated through the use of acoustical pulses of ultrasonic frequencies propagating in small-scale two-dimensional models. Specific examples include refracted waves in layers of finite thickness, air-coupled waves, compressional waves diffracted around the earth's core, and multiple arrivals from relatively simple configurations. The instrument may also be used as an analog computer to shorten the time required for numerical computations of lengthy and complex surface wave equations.

DNA in Diploid and Haploid Hybrid Frog Embryos

Betty C. Moore, *Columbia University*

After the Feulgen reaction, microspectrophotometric measurements have been made of the nuclear DNA of the early embryos of diploid and androgenetic *Rana pipiens* and of diploid and androgenetical lethal hybrids between *R. pipiens* ♀ × *R. sylvatica* ♂. The large, weakly Feulgen nuclei of the early blastula of *pipiens* ♀ × *sylvatica* ♂ have DNA values similar to those found in the smaller, darker-staining nuclei of the late blastula. These values vary from diploid to tetraploid amounts of DNA. Early androgenetic hybrid blastulas of *pipiens* ♀ × *sylvatica* ♂ were found to have nuclear DNA values similar to those found in late androgenetic hybrid blastulas. These values vary from haploid to diploid amounts of DNA. Late-blastula nuclei of diploid *pipiens* have DNA values similar to those of the late-blastula nuclei of the diploid hybrids. Late-blastula nuclei of the haploid *pipiens* embryos have DNA values similar to those of the late-blastula nuclei of the haploid hybrids. Thus no change in the nuclear content of DNA has been found during the formation of the blastula in either the diploid or haploid lethal hybrids. Further studies up to the time of the death of the hybrids are in progress.

It is of interest to note that the chromosomes of the blastulas form karyomeres which fuse to form double nuclei or hemikaryons in many cells. These are present in both the diploid *pipiens* and the diploid hybrids. Double nuclei appear in a few cells of the haploid *pipiens* and the haploid hybrids and may be a result of the incomplete fusion of the karyomeres.

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Probability of Seeing Functions for Near-Instantaneous Thresholds

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Probability of seeing as a function of stimulus intensity was measured for a circular stimulus area, 30 min in diameter, presented to the fovea. Measurements were made immediately following adaptation to intensities ranging from near cone threshold to 10,000 millilamberts. The procedure at each adapting intensity was as follows: after the eye was adapted to one of the adapting intensities, the cycling of adapting and test stimuli was begun. The period of this cycle was 10 sec and began with the interruption of the adapting stimulus. After a dark period of 0.2 sec the test intensity was presented. After another dark period of 0.4 sec the adapting stimulus came on for the remainder of the 10-sec period. This cycle was repeated until a complete frequency of seeing function was obtained.

Three subjects were run at 14 adapting intensities. Two exposure durations, 6 and 50 msec, were studied.

The average thresholds as a function of adapting intensity yield a function of the same general form as shown in earlier results in the literature. The maximum slope of the probability of seeing functions increases as the threshold increases and as the adapting intensity increases from near threshold to approximately 100 times this value. Changes in adapting intensity beyond this point have relatively less effect on the slope of the psychophysical function, and there is some indication that the slope decreases at high adapting intensities. The changes in slope that accompany the change in threshold at low adapting intensities are considered in relation to a "quantal" type of theory of the threshold effect.

Hyperfine Structure of the $n = 3$ $^2P_{1/2}$ and $^2P_{3/2}$ States of Sodium-23 by an Atomic-Beam Method

M. L. Perl, I. I. Rabi, B. Senitzky, *Columbia University*

The hyperfine structure of the $n = 3$ $^2P_{1/2}$ and $^2P_{3/2}$ excited atomic states of Na^{23} have been investigated using a modification of the atomic-beam method proposed by Rabi [*Phys. Rev.* 87, 379 (1952)]. The apparatus has conventional A and B inhomogeneous deflecting magnets, which are arranged so that a change of electronic moment is required for an atom to be refocused, that is, to hit the detector wire. A beam of sodium atoms in the ground state ($n = 3$ $^2S_{1/2}$) transverses the A magnet and enters the homogeneous C field region. Resonance radiation from a sodium discharge lamp illuminates the C region and excites part of the beam to the $n = 3$ $^2P_{1/2}$, $n = 3$ $^2P_{3/2}$, and possibly higher states. The excited atoms decay to the ground state before leaving the C field region, but in so doing, about one-third of them end up in hyperfine ground states having opposite electronic moments from their initial hyperfine ground states. These atoms are refocused and produce a signal depending on the light intensity.

If an oscillating magnetic field of a frequency corresponding to an excited-state hyperfine transition is applied in the C field region simultaneously with the optical radiation, some of the excited atoms change their excited hyperfine state before decaying. In our experiment this results in an increase in the number of refocused atoms. If the frequency of the oscillating field is varied across the transition frequencies of the excited-state hyperfine structure, the plot of increase in refocused atoms with frequency gives the spectra of the excited state.

Using this method with a near zero static magnetic field in the C region we have found the $F = 0$ to $F = 1$ line in the $^2P_{1/2}$ and the $F = 2$ to $F = 3$ line and the $F = 1$ to $F = 2$ line in the $^2P_{3/2}$ state. We have not been able to find the apparently weak $F = 0$ to $F = 1$ line in the $^2P_{3/2}$ state. By increasing the static magnetic field in the C region we have also studied the Zeeman and Paschen-Back effect in both excited states. At present the investigation of the sodium excited states is being continued and the method is being extended to other elements.

17-Keto-17a-Methyl-D-Homosteroids from 17α-Hydroxy-20-Amino-C_{21} Steroids: Stereochemistry of D-Homoannulation

Fausto Ramirez and Stanley Stafiej, *Columbia University*

The action of nitrous acid on a 17α-hydroxy-20α-amino steroid III ($R' = H$) (3β,17α-dihydroxy-29α-aminoallopregnane) has been studied with the view of (i) correlating the configurations at carbons 17 and 20 with the course of deamination and (ii) providing a new route to C_{21}-D-homosteroids. It was found that the amino alcohol III ($R' = H$) rearranged exclusively with migration of the 13-17 bond to a 17-keto-17a-methyl-D-homosteroid V (3β-hydroxy-17a-methyl-D-homoandrostan-17-one). This result is interpreted in terms of steric strain in the transition state of the deamination and is compared with the previously reported D-homoannulation of 17α-hydroxy-17-aminomethyl steroids, in which no steric bias is associated with carbon-20.

The amino alcohol III ($R' = H$) was obtained, together with a small amount of the 20β-epimer IV ($R' = H$), from the catalytic hydrogenation of a 17α-hydroxy-20-oxime (II) (3β,17α-dihydroxy-20-oximidoallopregnane). The configurations of the amino alcohols are based on the molecular rotation differences between the 20-epimeric acetamido derivatives (III, $R' = Ac$ and IV, $R' = Ac$) by comparison with previously reported molecular rotation differences of 20-epimeric 20-acetate derivatives of 17α,-20-dihydroxy steroids of analogous constitution (that is, products of the reduction of I at carbon-20). The oxime II (or its 3-monoacetate) was prepared in quantitative yield from 3β,17α-dihydroxyallopregnane-20-one (I, $R = H$) (or its 3-monoacetate, I, $R = Ac$).

Generation of Bioelectric Potentials

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Electric currents propagate impulses along nerve fibers and other conducting tissue. The source of the electromotive force of these currents is ionic concentration gradients: Na ions are much higher on the outside of the cell than in the interior. The opposite is true for K ions. During activity there is a sudden influx of Na^+ followed by an equivalent outflow of K^+. Knowledge of the mechanism by which nerve fibers suddenly become more pervious to Na^+ for a fraction of a millisecond, as physical recordings indicate, is fundamental to understanding nerve function.

Studies of chemical reactions and of the sequence of energy transformations associated with the generation of bioelectric potentials have shown that the acetylcholine system is essential for the change in ion permeability. Electric organs, the most powerful bioelectric generators created by nature, offered an important tool. The following picture of the elementary process has emerged.

Acetylcholine is present in a bound form. Released by a stimulus it acts upon a "receptor" protein which, in this reaction, apparently changes its configuration. This process seems to be responsible for the permeability change. The free ester is inactivated by the enzyme acetylcholinesterase; the receptor returns to its original condition, and the barrier for ions is reestablished. In the recovery process acetylcholine is resynthesized by the enzyme choline acetylase. The energy provided by ATP hydrolysis and the glycolytic and citric acid cycles are all essential in recovery mainly for restoring the disturbed ionic equilibrium. The molecular forces in the active surface of the various proteins of the system reacting with acetylcholine differ markedly in their reaction with quaternary nitrogen compounds compared to that with the tertiary analogs. Presence of a fourth alkyl group on the nitrogen does not markedly affect the binding forces but greatly enhances functional activity. This applies to the two enzymes as well as to the receptor protein: tertiary nitrogen compounds structurally analog to acetylcholine are able to block propagation, the quaternary analogs block and in addition simultaneously depolarize the cell, suggesting that they have a greater ability to produce the change of the receptor protein responsible for the increased permeability.

Ordering Processes in Cu_3Au

S. L. Quimby, *Columbia University*

Details of the several processes by which equilibrium order is achieved in specimens of Cu_3Au quenched from a temperature above the critical temperature to one below it, are revealed by F. P. Burns' measurements of the isothermal time variation of electric resistivity following the quench. Above about 360°C the initial process is the formation, by statistical fluctuation, of stable antiphase nuclei of low order in the disordered matrix. The nuclei grow until their boundaries are contiguous, and simultaneously the order within them increases to the equilibrium value for the temperature. The rate of fall of resistivity produced by this process *increases* as the quench temperature is lowered. The end-result is a mosaic of antiphase domains, and the succeeding process is the coalescence of these domains to form the highly stable structure compared by Bragg to that of a stable foam. Subsequent coalescence is extremely slow. Quantitative estimates of the nuclear size, based upon their computed surface and volume free energies, are consistent with x-ray measurements of domain size.

Below 360°C the density of nuclei is sufficiently great that the nuclear boundaries are nearly contiguous on formation. The dominant process following the formation of nuclei is domain coalescence. The rate of fall of resistivity *decreases* as the temperature is lowered.

The true kinetics of the ordering and disordering processes, freed from phenomena associated with antiphase domains, are revealed by measurements made on a specimen after annealing for upward of 50 hr. The observed time variation of resistivity following sudden changes of temperature below the critical temperature are in excellent agreement with the simple kinetic theory of bimolecular processes recently proposed by Jerome Rothstein.

Interaction of Instrumental and Autonomic Responses in Avoidance Conditioning

W. N. Schoenfeld, P. J. Bersh, J. M. Notterman,
Columbia University

Two experiments are reported testing the hypothesis that acquisition of any instrumental avoidance response (R_{AV}) weakens autonomic CR's (conditioned responses) acquired during avoidance training wherein both Pavlovian and Thorndikian paradigms figure. This weakening is predicted from the absence of US (unconditioned stimuli) on successful R_{AV} trials, and also from the discriminative control assumed by stimuli produced by, or accompanying, R_{AV}.

In these experiments, the CR under observation was the heart-rate depression developed in human subjects upon repeated exposure to tone (CS) followed by electric shock (US). CR was measured by comparing pretone heart rate with that in the CS-US interval. A trace conditioning procedure was used: 1-sec tone, 6-sec CS-US interval, 6-sec shock.

In experiment 1, 20 subjects were given eight trials each of CR acquisition, followed by R_{AV} (a key-tap during the fourth second of the tone-shock interval) acquisition by each subject to a criterion of five successive avoidances. Both the number of subjects (15 out of 20) with diminished CR's and the diminution in group mean CR indicate that during the avoidance criterion trials CR was significantly lower ($P < .05$) than during acquisition.

Experiment 2, with 10 new subjects, replicated experiment 1 with the exception that each successful R_{AV} during avoidance training was immediately followed by an exteroceptive signal (1.5 sec light). Again, both by the number of subjects (9 out of 10) with diminished CR's and by the diminution in group mean, CR during the avoidance criterion trials was significantly lower ($P < .02$) than CR during acquisition, this reduction being even greater than in experiment 1 because of the additional discriminative cue.

Both experiments thus confirm the original hypothesis.

Anatomy of the Magellanic Clouds

Harlow Shapley and Virginia McK. Nail,
Harvard University

The nearest of galaxies outside our own, the Magellanic Clouds at a distance of 170,000 light-years, are neither spiral nor spheroidal in form but of the less usual irregular type. The Large Cloud of Magellan, dominated by a long stellar axis or bar rather than a nucleus, can properly be classed as a quasi-barred spiral. Our current investigations concern the dimensions and topography, the dark and bright nebulosities, the supergiant stars, and the star clusters in both Clouds.

Of most interest is our study of the 300 cepheid variable stars scattered along the bar of the Large Cloud. We seek to find what light these cepheids can throw on the tilt of the bar and on the tilt of the whole Cloud with respect to the tangential plane. It is not yet proved, however, that the Large Cloud is a flattened system. Eventually, as the precision of the photometry increases and our information about the location and motions of the hydrogen gas in and surrounding the Large Cloud is extended by the radio-telescopes at Sydney, Australia, we should unravel both the form and the inner turbulences of this important galaxy.

Unexpectedly we find that the cepheid variables at the west end of the Large Cloud's bar, simulating the cepheids in the core of the Small Cloud, are preferentially larger, brighter, and of longer period than in the center or at the east end.

Our recent work has shown that many of the supergiant stars are reddish, variable, and in radiation exceed the sun 50,000 times. A few of the bluish supergiant stars in the so-called "constellations" within the Large Cloud radiate at a rate in excess of 200,000 suns, and thus we have the remarkable situation in which a single star emits more radiant energy than is emited by all the tens of thousands of giant and average stars in the average globular star cluster.

Olation in Certain Basic Metallic Salt Solutions

Arthur W. Thomas, *Columbia University*

The polymerization in aqueous solution of basic chromic, ferric, and aluminum ions to form polyolated and/or polyoxolated complexes is briefly discussed, especially with regard to determinations of rates of such reactions.

In vivo Conversion of C_{21}-17α-Hydroxylated Steroid to C_{21}-17-Desoxymetabolites

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Seymour Lieberman, Joseph W. Jailer,
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As the title indicates, proof has been obtained for the existence of a novel metabolic pathway for the catabolism of adrenal steroids. 11β,17α-Dihydroxy-4-pregnene-3,20-dione (21-desoxy hydrocortisone) was administered to two Addisonian patients whose ketosteroid excretion values at the time of the experiment were 4.0 and 4.4 mg/day, respectively. The urinary metabolites of the administered compound were isolated by gradient elution chromatography. Along with several unidentified compounds, the following steroids (not present in control urines) were identified by infrared spectroscopy: 11-keto-androsterone, 11-keto-etiocholanolone, 11β-hydroxy-androsterone, 11β-hydroxy-etiocholanolone, 3α,17α-dihydroxy-pregnane-3,11,20-trione and 11-keto-pregnanolone (3α-hydroxy-pregnane-11,20-dione). The recovery of the last-named compound (identity confirmed by melting point and mixed melting point) establishes the existence of an *in vivo* metabolic pathway by which a tertiary 17α-hydroxyl group of a C_{21}-steroid is replaced by hydrogen.

The presence of this pathway has been confirmed by another experiment in which 17α-hydroxy-progesterone was given to another Addisonian patient who was excreting no discernible ketosteroids at the time of the experiment. Pregnanolone (identity by melting point, mixed melting point, and infrared spectra) was isolated from the urine, and this again demonstrates the metabolic elimination of the 17α-hydroxy group. The importance of this finding for the establishment of hormonal precursor-metabolite relationships is discussed.

Cross Section of Hydrogen Compounds for Very Slow Neutrons

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For low-energy neutrons the theoretical value of the cross section of hydrogen bound tightly to an infinitely heavy atom should be about 81 barns [Fermi, *Ricerca sci.* **7,** 13 (1936)]. The effective *n-p* cross section is considerably increased in molecules where the neutron can either gain or lose energy by interactions involving molecular motions [Arley, *Kgl. Danske Videnskab. Selskab Mat. fys. Medd.* **16,** 1 (1938)]. To study this effect, the cross sections of gaseous methane (CH_4) at two different temperatures, liquid water (H_2O), polyethylene ($(CH_2)_x$), and barium hydride (BaH_2) have been measured for neutrons with wavelengths from 3.5 to 10 A. These measurements were made at Brookhaven National Laboratory with the slow neutron chopper [Seidl *et al., Phys. Rev.* **82,** 345 (1951)] and a crystal monochrometer using mica in conjunction with filters to remove diffracted neutrons of higher orders.

The cross section of methane is nearly linear with wavelength from 4 to 10 A where it changes from 312 to 685 barns per molecule. Subtracting the absorption cross section of hydrogen and the scattering cross section of carbon and then dividing by 4 to obtain an effective cross section per proton in the molecule gives 76 barns at 4 A and 168 barns at 10 A or a slope of 15.3 barns/A. At $-78°C$ the effective cross section per proton in the molecule was reduced to 77.6 barns at 5 A and 99.9 barns at 7 A, giving a slope of 11.2 barns/A. Changes in translation and rotation of the methane molecule should account for the major part of this decrease in cross section. A theoretical treatment is in progress, but it has not yet been completed.

Curves for the effective cross section per proton for water and for polyethylene as a function of neutron wavelength are nearly the same in the wavelength range from 4 to 10 A, varying from about 81 to 121 barns with a small curvature. The curve for barium hydride follows that to be expected from a proton bound tightly to a heavy atom up to about 5 A; it then increases slowly from 70.5 barns at 5 A to 77 barns at 10 A.

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Nucleocytoplasmic Interchange in Oocytes

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Ultrathin sections (0.02 to 0.05 μ) of frog ovaries that were fixed in osmium tetroxide have been studied with the electron microscope. In early oocytes, before yolk deposition, the nuclear boundary, or membrane, appears in vertical section as a series of evenly spaced dense bodies interspersed with a continuum of much lower density. In tangential sections of the membrane these bodies appear circular, with a peripheral ring of denser particles; commonly there is also a central body, similar to those in the ring. From the outer surface of each of the large dense bodies there projects into the cytoplasm an unbranched, threadlike, structure, which appears to be nodulated, or to show a suggestion of helical form. From the inner surface of each large dense area a delicate, highly contorted thread extends into the nucleus, sometimes terminating in the nucleolus. In sum, these appearances at the nucleocytoplasmic boundary seem consistent with the view that the large dense areas are regions where a threadlike substance is continuous from nucleus to cytoplasm.

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Historical Geology, Dynamic Geology, and Recoverability

Arthur N. Strahler, *Columbia University*

Geology is concerned with two fields of inquiry: (i) Physical, or dynamic, geology is a study of the geologic processes and the characteristic forms they produce. (ii) Historical geology reconstructs a series of events and assemblage of forms produced at a particular place and time in the past. A more fundamental distinction between the two fields may be made by introducing the concept of probability of repeated occurrences of given states of matter. In this light, dynamic geology deals with forms and events that may be expected to recur frequently in geologic time and, therefore, provide the basis for formulation of general laws and for offering predictions. Historical geology, on the other hand, describes assemblages of geologic forms and sequences of events so complex that probability of repetition at any place or time, past or future, is extremely small, and the particular state is therefore virtually irrecoverable.

Under these definitions we can reject as trivial the distinction accepted by Kirk Bryan and Leland Horberg in which the sole criterion for differentiating between dynamic and historical geology is whether the processes involved are acting now or have ceased to act.

Function of the Right Ventricle—an Obscure Hydraulic Problem

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Since the time of Harvey, the heart has been regarded as a four-chamber pump. For some time it has been recognized that the auricles are of only subsidiary importance; their pumping action can be spared. During the past decade it has been proved experimentally that up to 80 percent of the right ventricular walls can also be destroyed without affecting the transfer of blood through the lungs to the left heart—even under stress of greater pulmonary resistance or exercise. Clinically, such demonstrations should question diagnoses of right-heart failure.

Physiologically, the source of energy through which the right ventricle still functions with almost normal efficiency has no satisfactory explanation. The suggestion that the propulse action of the damaged right ventricle is caused by a pull of left ventricular muscle bands upon continuous, but damaged, bands of the right ventricle (Bakos) does not square with the demonstration that the right ventricular wall is not pulled in but expands during ejection of blood (Kagan). The concept that the right ventricular wall has so great a factor of safety that 20 percent of scattered contractile elements can take over the work of the right ventricle, even under stress (Donald and Essex), is untenable, because (i) the ventricular wall, as a whole, does not contract but bulges, and (ii) in the same animal, the ability of the damaged ventricle to overcome a measured pulmonary resistance is surprisingly little less than that of the undamaged ventricle (Kagan).

The concept that shortening of the apex-base axis of the thick interventricular septum may be largely responsible for creation of pressure in the right ventricle (Kagan) is not supported by the following evidence. (i) The relative onset and offset of right and left ventricular systoles can vary from time to time. (ii) Artificial excitation causes precedence of contraction and a more gradual rise to a lower maximum systolic pressure only on the side stimulated. (iii) The contractile force may increase in one ventricle and diminish in the other. (iv) Normally, shortening of surface fibers is proportional to the pressure developed in the right ventricle. (v) In defects of the ventricular septum, the initial push of blood into the pulmonary artery is given by the right ventricle and is completed by a delayed auxiliary force from the left ventricle.

Gravity Anomalies at Continental Margins

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Gravity anomalies along seven profiles across the eastern continental margin of the United States from Cape Hatteras to Nova Scotia are presented. Geologic sections along the profiles are deduced from the gravity anomalies with the aid of available seismic evidence in the area. The transition from ocean-type to continental-type structure at continental margins is discussed in the light of this gravity evidence.

Intermediate Coupling Theory for Nuclear Reactions

E. P. Wigner, *Princeton University*

Almost all nuclear cross sections exhibit, at not too high energies, a kind of line structure with rather sharp maxima and relatively low values between the maxima. It was believed, until rather recently, that the frequency and width of the states, which are responsible for the line structure of nuclear cross sections, are rather smooth functions of the energy of the incident particle. However, more recent experiments of Barschall have definitely demonstrated that the product of the density and width of these states shows large-scale fluctuations. Furthermore, a satisfactory account of the energy dependence of this product was given by Feshbach, Porter, and Weisskopf and by Adair by means of their clouded crystal ball model.

It was pointed out in earlier work with Eisenbud and with Teichmann that, in the independent particle model, only the states based on the unexcited target nucleus have a finite width and, hence, that only these contribute to the cross section. In the many-particle model, these states share their widths with other states. If one assumes that, as a result of this sharing, all states have about the same width, the cross section will show no gross structure. Such a gross structure is obtained, however, in the intermediate case of some, but not complete, sharing of the width among the states. In this case, the levels close to the original single-particle state obtain the lion share of the width that the single-particle state possessed originally. The distance, in energy scale, of the states that still acquire an appreciable width is directly given by the deviation from the single-particle picture. According to the model arrived at, the gross structure in the cross section is the result of fluctuations in the width, rather than the density, of the states responsible for the line structure. It appears possible also to find an explanation for the angular dependence of the velocities of the reaction products.

Reactivation of Enzymes Inhibited by Certain Highly Toxic Agents

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Certain phosphate esters such as tetraalkylpyrophosphates, dialkyl fluorophosphates, and dialkyl p-nitrophenylphosphates are potent irreversible inhibitors of acetyl cholinesterase, an enzyme, vital for nerve function. Some important insecticides and the most toxic chemical warfare gases are of this type and owe their poisonous character to the inhibition of acetylcholinesterase. Since the action of these compounds is not restored by dilution or dialysis, it was held that the enzyme activity was irrevocably destroyed by these compounds. But the development of enzyme theory clarified the mechanism of inhibition and suggested means of reactivation. During the hydrolysis of carboxylic esters an acylated enzyme is formed that reacts rapidly with water to regenerate the active enzyme. In the case of these irreversible inhibitors the enzyme is phosphorylated, but in contrast to the acylated enzyme the phosphoryl enzyme reacts only very slowly with water. These compounds are, therefore, not substrates.

Theory suggests that reagents capable of making a nucleophilic attack on the phosphorus atom should regenerate the enzyme in an essentially SN_2 reaction. And in fact, compounds containing amino, hydroxyl amino, pyridyl, guanidino, amidino, hydroxyl, or mercaptyl groups are effective reactivators.

In addition to the esteratic binding site, this enzyme contains an anionic site which contributes to the catalytic action of the enzyme by binding and orienting cationic ammonium structures such as those contained in the physiological substrate acetylcholine. This site is not directly affected by these inhibitors and still functions in the inhibited enzyme. Accordingly the best reactivators are the compounds, such as nicotinehydroxamic acid methiodide, that contain a nucleophilic group and a cationic ammonium structure.

A Homomorphism Sequence Based on Loops

P. A. Smith, *Columbia University*

Let K be a connected geometric complex. We associate to K a homomorphism sequence of order 2:

$$\rightarrow F_n \rightarrow F_{n-1} \rightarrow \qquad \rightarrow F_1 \rightarrow 1,$$

in which F_1 is the group of combinatorial loops with fixed base point and F_m is abelian for $m > 2$. The construction is purely algebraic and is suggested by homotopy, rather than homology, concepts. The groups

$$p_n = \text{kernel } (F_n \rightarrow F_{n-1}) / \text{image } (F_{n+1} \rightarrow F_n)$$

are invariant under standard operations on complexes but, except for $p_1 = \pi_1$ and $p_2 = \pi_2$, have yet to be identified under general conditions. On the other hand, if $p_1 \ldots p_{n-1}$ are trivial then p_n is the integral n-dimensional homology group based on finite classes. For a 2-sphere p_3 is infinite.

Role of Thioesters of Amino Acids in the Synthesis of the Amide Bond

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The role of acyl mercaptans in the synthesis of fatty acids suggests the possibility that amino acids in thioester linkage with SH groups either of enzymes or of coenzymes as yet not recognized act as intermediates in peptide synthesis. Such intermediates may be most easy to demonstrate in the biosynthetic reactions involving the γ-carboxyl of glutamic acid as in glutamine or glutathione (GSH) synthesis. A study of the behavior of model substrates under enzymatic and nonenzymatic conditions offers an experimental approach to this problem.

Both α- and γ-thioesters of glutamic acid with glutathione as the mercaptan were synthesized in an unequivocal manner. The γ-isomer decomposed rapidly into GSH and pyrrolidone carboxylic acid. S-α-glutamyl-GSH and both isomeric thioesters of carbobenzyloxy glutamic acid and GSH were split by a thioesterase preparation from brain and liver. Different ammonium sulfate fractions of liver showed constant ratios of activity toward the glutamic-acid thioesters and toward S-acetyl-GSH. However, this was not observed for other aminoacyl and acyl mercaptans. In aqueous solution at *p*H 7.6 S-α-glutamyl-GSH was converted to an extent of about 50 percent to N-α-glutamyl-GSH by transfer of the glutamyl radical from the thioester bond to the α-amino group of GSH with formation of an α-peptide linkage.

Studies on the Chemistry of Mutation

Stephen Zamenhof, *Columbia University*

The purpose of this work (done in collaboration with Hattie E. Alexander and Grace Leidy) is to study the correlation between the change in chemical structure and the change in function of one alleged hereditary determinant, DNA. The results obtained in this laboratory suggest that the removal of less than ½ percent of total amino groups (and/or hypothetical H-bonds to these groups) results in total inactivation of DNA. On the other hand, we find that the replacement of more than 10 percent of methyl groups in thymine (of DNA) by bromine or iodine does not result in either inactivation or demonstrable mutation. The cells with such unnatural DNA may grow at a normal rate and cannot be distinguished from the normal ones. This seems to indicate that while certain profound changes in the structure of the DNA molecule may be without consequences, the maintenance of the original pattern of electric charges is essential.

In nature, the heritable change of this pattern may occur through change of sequence and/or proportion of nucleotides in an integral DNA molecule. This process can be visualized at present only as a (rare) fault occurring during DNA reproduction; this process, then, may be the chemical basis of mutation. However, the probability and the location of the fault along the DNA molecule may be determined by a preceding process postulated as gene unstabilization. We find that this unstabilization occurs also in DNA *in vitro* under the action of various mutagenic agents. On reproduction, the unstabilized DNA becomes again stable.

RaE β-Spectrum and the Pseudoscalar Interaction

C. S. Wu, *Columbia University*

The radiations from RaD and RaE have been systematically studied in this laboratory. The RaE β-spectrum has been reinvestigated in the solenoidal magnetic spectrometer. By taking into consideration the effect of a finite de Broglie wavelength, the β-spectrum can be fitted with a linear combination of (S,T) and a spin and parity change of $1^- \rightarrow 0^+$. This is in good accord with the determination of the spin of RaE. Existence of the pseudoscalar interaction will be discussed.

Vacuum Polarization in a Strong Coulomb Field

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Columbia University

One interesting and important consequence of the Dirac hole theory is the appearance of a charge density in the vacuum simply as a consequence of the application of an electrostatic field. This induced charge density, generally referred to as the vacuum polarization charge density, has been previously calculated for the case of a weak field of arbitrary form and for a uniform field of arbitrary strength. Furthermore, its existence has been experimentally verified in connection with the fine structure of hydrogenic atoms.

The case of a strong coulomb field is of interest in connection with experiments that explore the nuclear electrostatic field in detail, since the polarization charge will, of course, modify this field. There is also some general theoretical interest in the avoidance of weak-field approximations and in the convergence of the power series expansion in the parameter which characterizes the field strength, in this case, the nuclear charge.

To deal with this problem we make use of the fact that the polarization charge can be expressed in terms of the solutions to the Dirac equation, which, for the case of the coulomb field, are known. These solutions can be used to express the Laplace transform of the charge in a relatively tractable form. The power series expansion of the Laplace transform can be shown to converge for all values of the nuclear charge for which the Dirac equation has proper solutions. The behavior of the polarization potential at small distances has been discussed completely. The corrections to the weak-field approximation are small for all allowable values of the nuclear charge.

Rice and Health in Asia

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In the most populous parts of Asia rice is the staple food. From it is derived 80 to 90 percent of the daily caloric intake of some 800 million people. In large areas of Asia, though not in all, overcrowding of the land forbids diversification of diets with large components of foods of animal origin.

Correction of the nutritional shortcomings of rice by undermilling it, parboiling it, or reenforcing it with products of chemical manufacture presents the only possible early, though partial, solution of Asia's food problems. The possibilities and progress to date are reviewed with special reference to the Philippine as a trial area.