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Structural Modifications of Histones and their Possible Role in the Regulation of RNA Synthesis

In a study of histone biosynthesis in isolated calf thymus nuclei, it was observed that different histones are actively labeled by acetate-2-C^{14}. This acetylation was particularly marked in an arginine-rich histone fraction which was purified by column chromatography. The uptake of acetate-2-C^{14} into histones was not inhibited by agents, such as Puromycin, which suppress the uptake of amino acids into nuclear proteins. It can be concluded that acetylation of the histones very probably occurs after completion of the polypeptide chain.

Cell nuclei also modify the structure of histones by methylation of the epsilon-amino groups of the lysine residues in the protein. The methyl group donor for the reaction is methionine. Puromycin has no effect on the transfer of C^{14}-methyl groups from methionine to histones, and it is likely that methylation takes place after synthesis has occurred.

When isolated histones of the arginine-rich type are subjected to a limited acetylation, they lose much of their original capacity to inhibit ribonucleic acid synthesis, as tested by adding such histones to the DNA-dependent RNA polymerases of calf thymus nuclei or *Escherichia coli*. Yet, such modified histones are still strongly basic proteins with an affinity for DNA comparable to that of the parent histone from which they were derived.

The findings suggest the possibility that relatively minor modifications of histone structure, taking place on the intact protein molecule, offer a means of switching RNA synthesis on or off at different loci along the chromosome.

VINCENT G. ALLFREY
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The Anelasticity of the Earth

The elastic properties of the earth are now very well known. The travel times of short-period seismic waves, the dispersion of long-period surface waves, and the free periods of vibration of the whole earth have been used to obtain a detailed and consistent picture of the response of the earth to short-term, small-amplitude stresses. The departure from perfectly elastic behavior is important in discussions of tidal yielding, shape and thermal history of the earth, variations in length of day, continental and polar wandering, mountain building, mechanism of earthquakes, and post-glacial rebound. The attenuation of seismic waves is one manifestation of the earth's anelasticity and is not unrelated to the response of the earth to stresses of longer duration. The decrease in amplitude of successive passes of world-encircling surface waves past a single station, the decay of the free oscillations with time, and the widths of the free oscillation resonance peaks can be used to recover the distribution of anelastic properties in the earth. It is shown that maximum departure from perfect elasticity occurs in the region of the upper mantle from 100 to 400 km depth. This is also a region of low seismic velocities. A rapid increase in the quality of mantle material sets in at 400 km which is interpreted as a phase change at this depth. The lower mantle seems to be significantly below the melting point, which probably precludes extensive mantle-wide convection.

DON L. ANDERSON
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Aqueous Solution Chemistry of Xenon

Both XeF_4 and XeF_6 react with water to produce XeO_3, a nonvolatile white solid. XeO_3 readily dissolves in water to give Xe(VI) solutions. These solutions are stable but they are strongly oxidizing. The Xe-Xe(VI) potential is estimated to be 1.8 volts in acid and 0.9 volt in base.

In strongly basic solutions ozone oxidizes Xe(VI) quantitatively to Xe(VIII). Xe(VIII) can also arise by disproportionation of Xe(VI) in strong base. Insoluble sodium and barium salts of Xe(VIII)-perxenates have been isolated and characterized with compositions $Na_4XeO_6 \cdot 2H_2O$ and $Ba_2XeO_6 \cdot 1.5\ H_2O$.

Aqueous solutions of sodium perxenate evolve oxygen slowly to give Xe(VI). The reaction is almost instantaneous below *p*H 7. Octavalent xenon is an extremely powerful oxidizing agent, rapidly oxidizing iodate to periodate and manganous to permanganate. The Xe(VI)-Xe(VIII) potential is estimated at 3.0 volts in acid and 0.9 volt in base.

Based on work performed under the auspices of the U.S. Atomic Energy Commission.

E. H. APPELMAN, J. G. MALM
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Oxygen Evolution Coupled with Photoreduction of Ferredoxin by Chloroplasts

Chloroplast ferredoxin, a red, water-soluble, iron-containing protein, is reduced in the light by the chlorophyll-containing portion of chloroplasts (grana). As we have recently reported: (i) reduced ferredoxin is the strongest chemically defined reductant that has been isolated so far from the photosynthetic apparatus of green plants (it has a redox potential about 100 mv more electronegative than that of reduced pyridine nucleotides); (ii) photoreduction of ferredoxin is accompanied by photophosphorylation (ATP formation). These findings point to the photoreduction of ferredoxin by chloroplasts as the final step in the primary conversion of radiant energy into chemical energy. All the subsequent reactions of photosynthesis in isolated chloroplasts which lead to CO_2 assimilation are concerned with storage of chemical energy and are, on present evidence, independent of light. They involve, apart from the consumption of ATP, a utilization of the photochemically reduced ferredoxin.

A notable feature of the photochemical activity of isolated chloroplasts is the evolution of oxygen. Although

photoreduction of ferredoxin has been experimentally separated from oxygen evolution, the two events must be coupled if ferredoxin is indeed the final physiological electron acceptor in the photochemical reactions of chloroplasts. Evidence for this has now been obtained with illuminated chloroplasts supplied with "substrate" amounts of ferredoxin as the sole electron acceptor. Photoreduction of ferredoxin was accompanied by oxygen evolution. A consistent stoichiometry of 4 ferredoxins reduced to 1 O_2 evolved was observed with different concentrations of added ferredoxin, confirming previous results that one electron is required to reduce one molecule of ferredoxin. Oxygen evolution was measured polarographically with a platinum electrode modeled after that of Hagihara, and photoreduction of ferredoxin was measured spectrophotometrically at 420 mμ.

It now appears that under physiological conditions photoproduction of oxygen by chloroplasts always requires ferredoxin. However, chloroplasts will also produce oxygen, in what is known as a Hill reaction, when ferredoxin is replaced by one of a number of nonphysiological electron acceptors.

DANIEL I. ARNON, HARRY Y. TSUJIMOTO, BERAH D. MCSWAIN
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Properties of Mitochondrial Contractile Protein and Actomyosin of Heart Muscle

Procedures have been developed (i) for the isolation of contractile protein from heart muscle mitochondria, free of both myofibrils and actomyosin; (ii) for the isolation of cardiac actomyosin. The contractile protein, relatively free of electron transfer components, qualitatively resembles actomyosin with respect to adenosine triphosphatase (ATPase) activity, change in relative viscosity induced by ATP, superprecipitation, and fiber formation.

The two proteins exhibit their maximal intrinsic ATPase activity near *p*H 6.0 and 8.5 and a minimum at neutrality. Ca^{++} has been shown to stimulate the ATP hydrolysis at all ionic strengths, and Mg^{++} to inhibit except at very low ionic strengths. Cd^{++} was stimulatory at low concentrations but inhibitory at high concentrations. The ATPase activity observed in the absence of added divalent metals was dramatically reduced when "Ca free" ATP was used and the actomyosin was washed with EDTA. However, activity could be restored by catalytic amounts of Ca^{++}. The superprecipitation caused by ATP was most pronounced in the presence of Mg^{++}. The change in viscosity induced by ATP was affected by the ionic strength and could be induced by agents other than ATP. The actomyosin was shown to have an inherent myokinase activity highly dependent on Mg^{++}.

Preliminary observations have indicated that less than three molecules of ATP are required per molecular weight unit of actomyosin to obtain a complete conformational change which is over 60 percent reversible. The actomyosin preparation contains approximately 6 percent phospholipid which on modification with phospholipase causes a variable response in the ATP-induced conformational change. The available evidence indicates that the mitochondrial contractile protein and the muscle actomyosin have very similar properties and may perform similar functions.

P. V. BLAIR, J. F. PERDUE, D. E. GREEN
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Galactolipids and Photosynthetic Oxygen Evolution

Galactosylglycerides rich in α-linolenic acid have been identified as major lipid constituents of the chloroplasts in higher plants, in algae, and in certain phytoflagellates. A specific role for α-linolenic acid containing galactolipids in photosynthetic oxygen evolution [Erwin and Bloch, *Biochem. Z.* **338**, 496 (1963)] is indicated by the following observations. The high content of galactolipids and of α-linolenate in photoauxotrophic *Euglena gracilis* is reduced to negligible levels when these organisms are adapted to heterotrophic growth in the dark. High CO_2 concentrations which stimulate the Hill reaction also raise the α-linolenate content of algal cells. Abolition of the Hill reaction in the alga *Ankistrodesmus braunii* by growing cells on manganese-deficient media leads to a cessation of α-linolenate synthesis. Two algal mutants, which lack the ability to evolve oxygen, mutant 11 of *Scenedesmus obliquus* D_3 [Bishop, *Nature* **195**, 55 (1962)] and mutant Ac141 of *Chlamydomonas reinhardii* [Levine and Smillie, *J. Biol. Chem.* **238**, 4052 (1963)] contain some α-linolenate but no detectable amounts of galactosylglycerides. Both galactose and α-linolenate appear to be necessary constituents of the lipid associated with photosynthetic oxygen evolution.

KONRAD E. BLOCH, S. B. CHANG
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Chemically Defined Templates and Initiators for Deoxypolynucleotide Synthesis

Polydeoxyadenylic acid (poly dA), synthesized by a *terminal* deoxynucleotidyl transferase from calf thymus gland, serves as a template for DNA polymerase (*replicative* deoxynucleotidyl transferase) only after a lag period. Addition of oligo-d($pT_{n\geq 5}$) to the poly dA templated reaction mixture initiates immediate synthesis of the complementary poly thymidylate chain. Addition of oligo-d($pT_{n\leq 5}$), -d(pA_n), or -d(pX_n) does not initiate synthesis. Poly dA:dT synthesized on a poly dA template having $S_{20,w} = 3.4$, A^{260}/μmole P = 8.7, and $A^{280}/A^{260} = 0.32$, has $S_{20,w} = 6.9$, A^{260}/μmole P = 6.7, and $A^{280}/A^{260} = 0.58$. These values are not dependent upon presence or absence of initiator. The enzyme-formed complexes melt sharply with $T_m = 70.7$ in .15*M* NaCl : .015*M* Na citrate and regain hypochromicity completely upon cooling. Poly dA forms a broad band ($\sigma \approx 1.98$ mm) in Cs_2SO_4 density gradients while the dA:dT bands are appreciably narrowed ($\sigma \approx 0.89$ mm). Alkaline denaturation of initiated dA:dT followed by centrifugation in alkaline Cs_2SO_4 produces a broad band near the center of the gradient and a second band at the bottom. dA:dT isolated from uninitiated synthesis does not produce two bands under similar conditions.

F. J. BOLLUM
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New Evidence on Rigidity in the Earth's Core

Three lines of evidence have been brought to bear on the question of rigidity in the lower part of the earth's core, namely: (i) theoretical work of the author on density gradients in chemically inhomogeneous regions of the earth; (ii) the P seismic velocity distribution recently derived by Bolt for the core; (iii) evidence assembled by Birch indicating that the earth's central

density does not exceed about 13 g/cm³.

The parts of the earth's core specially considered are the region F, for which $1.21 < r < 1.66 \times 10^8$ cm, and the region G, for which $r < 1.21 \times 10^8$ cm, where r is the distance from the center. It is shown that in order to fit (i), (ii), and (iii), it is necessary both that the rigidity should be significant in G and that the rigidity should diminish with increasing depth. The same must also apply in the region F unless the central density is permitted to be at least 13.5 g/cm³. Thus the suggestion arises that the earth's core may have its two innermost zones both solid.

Seven model representations of the variation of the density ρ, incompressibility k, and rigidity μ in the lower core, all compatible with the data in (ii) have been constructed with a view to showing the consequences of particular types of assumptions on ρ, k, and μ.

K. E. BULLEN
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An Attempt to Apply the Temperature Jump Technique to Enzyme Reactions in Tissues

The temperature jump method has been particularly useful in the study of the kinetics of enzyme reactions in vitro (*1*) and in bioluminescent systems (*2*). Methods for continuously monitoring intermediates in intracellular enzyme systems have been developed (*3*) and applied to the tissues of small animals (*4*) where the fluorescence of mitochondrial and cytoplasmic DPNH (*5*) is excited at 366 mμ and measured at 450 mμ. Temperature jumps in small tissue volumes in the field of fluorometric observation are reported, using 0.4-msec trains of pulses of 1.5 joule total power at a wave-length of 693 mμ from a ruby maser focused obliquely to a spot roughly 1 mm × 0.3 mm. The fluorometer (*6*) has an aperture diameter of 0.2 mm, and is provided with a vibrating vane in the image plane that is synchronized with the flash to guard the photomultiplier. The photomultiplier is exposed about 2 msec after the flash and records the fluorescence intensity every 16 msec. Excised toad sartorius muscle shows large oxidation-reduction changes of DPNH (*7*) which can also be measured fluorometrically in vivo. This muscle at 23° is much more resistant to damage by the maser flash than soft tissue (rat kidney and brain at 38°) and little or no damage to the surface of the fascia or the underlying muscle is observed microscopically. The fluorescence shows a very rapid decrease of about 8 percent (due to lowered quantum efficiency with increased temperature) followed by an increase of about 20 percent, reaching a peak 200 msec after the flash. An exponential recovery to within 4 percent of the initial fluorescence level in 3 to 4 minutes follows. A small thermocouple placed 0.2 mm from the spot irradiated shows a 10° rise, and fast recovery. The muscle responds to electrical stimulation after a series of flashes on its surface. Apparently the maser flash imposes a rapid reversible transient on the metabolizing tissue due to a temperature jump. The effect is tentatively attributed to an activation of glycolytic enzymes, possibly a glycogenolysis.

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References

1. Czerlinski and Eigen, *Z. Elektrochem.* **63**, 652 (1959).
2. Kreezer and Kreezer, *J. Cellular Comp. Physiol.* **30**, 173 (1947).
3. Chance, *Nature* **169**, 215 (1952).
4. ———, Cohen, Jöbsis, Schoener, *Science* **137**, 499 (1962).
5. Duysens and Amesz, *Biochim. Biophys. Acta* **24**, 19 (1957); Chance and Baltscheffsky, *J. Biol. Chem.* **233**, 736 (1956).
6. Chance and Legallais, *J. Inst. Elec. Engrs. London* BME-**10**, 40 (1963).
7. Jöbsis, *J. Gen. Physiol.* **46**, 905 (1963).

Fluorides and Oxides of Noble Gases

Simple compounds of xenon that have been prepared and well characterized are XeF_2, XeF_4, XeF_6, $XeOF_4$, XeO_3, and XeO_4. Various measurements have been made to obtain structural information about them. These include the methods of infrared and Raman spectroscopy, x-ray diffraction, nuclear magnetic resonance, magnetic susceptibility, and Mössbauer spectroscopy. The fluorides are found to be similar in bonding to interhalogens.

Simple valence bond descriptions and molecular orbital treatments have correctly predicted symmetries for the difluoride and tetrafluoride molecules, but the two approaches lead to different predictions for the hexafluoride. XeF_2 is linear and symmetric and XeF_4 is square-planar. Unfortunately, experimental difficulties have thus far prevented a definitive determination of the hexafluoride structure.

Experimental evidence shows that the $XeOF_4$ structure is a square pyramid with the xenon atom close to the plane of the four fluorines and the oxygen atom at the apex, XeO_3 is pyramidal and XeO_4 is tetrahedral.

Of the other noble gases radon has been found to form at least one fluoride, but its formula is not known. Krypton is known to form both di- and tetrafluorides, but these are unstable at room temperature.

Based on work performed under the auspices of the U.S. Atomic Energy Commission.

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The Cause of Gastric Ulcers

In previous reports before this Academy, evidence was presented indicating that pure gastric juice unmixed with food can digest the normal mucosa of the stomach or duodenum and produce a chronic progressive ulcer. The mucosa is exposed to pure gastric juice when secretion is stimulated by agencies other than food or when the secretion is so excessive that the buffering effect of the food is overcome. Duodenal ulcers are usually caused by a hypersecretion of gastric juice of nervous origin, in turn due to the tensions of modern life. Gastric ulcers are usually caused by a hypersecretion of gastric juice of hormonal origin due to stasis of food in the stomach. Prolonged contact of food with the antrum of the stomach causes continued liberation of gastrin and stimulation of gastric secretion. Stasis may be due to deficient gastric peristalsis or to stenosis of the pylorus. Gastric ulcers develop in rabbits and in man if diminished gastric motility is produced by cutting the vagus nerves to the stomach, but they do not appear if an accompanying drainage operation is done to prevent stasis. The experimental production of stenosis of the pylorus in dogs produces stimulation of gastric secretion and chronic ulcers in these animals. Narrowing of the pylorus in man as a result of a duodenal ulcer causes the development of a secondary gastric ulcer. Transplantation of the antrum of the stomach into the colon in dogs causes excessive release of gastrin, excessive secretion of gastric juice, and typical chronic progressive ulcers

in the stomach, duodenum, or jejunum. Gastric ulcers in man heal if the antrum is removed, or if stasis of food in the stomach is overcome, coupled with division of the vagus nerves to the stomach to reduce the sensitivity of the gastric glands to secretory stimulation.

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The Problem of Callose Deposition in Phloem

Investigators generally agree that massive accumulations of callose on sieve plates are related either to the normal cessation of function of the sieve element or to one resulting from injury. But the question whether the relatively small amounts of callose observed in active sieve elements are deposited without reference to any injury is controversial. Some investigators think that callose deposition is an extremely sensitive and rapid reaction to injury and that therefore the presence of callose in any amounts may be suspected of being a response to some disturbance.

Callose deposition in sieve elements of *Impatiens sultanii* was studied experimentally. In response to wounding made by cutting the stem, callose was detectable in increased amounts near the wound only 5 minutes or more after wounding and the response extended through only 15 sieve elements (each 150 to 250 μ long) from the wound. After 30 minutes or more the sieve plates were completely plugged. To study sieve plates in rapidly killed phloem uncut shoots were immersed in boiling water or liquid nitrogen or were crushed between blocks of solid carbon dioxide or blocks of aluminum heated to 120° to 140°C. The tissues were found to be killed in seconds but callose was present in usual amounts and patterns of distribution characteristic of active sieve elements in sectioned material. The results are interpreted as suggesting that callose is normally present in the sieve elements of the plant investigated.

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A Detection Method and Probabilistic Models for Assessing Information Processing from Brief Visual Displays

The experimental situation of concern is one in which a visual display comprising a number of discrete elements, in the present study randomly selected consonants, is presented tachistoscopically for an interval short enough to permit only a single fixation. Questions of primary interest are: (i) How much information in the display is reflected in selective responses by the subject; and (ii) is the information associated with individual elements of the display processed simultaneously or serially?

Evidence bearing on the first question was obtained, firstly, by the classical procedure of verbal report, and secondly, by a discrimination procedure in which the subject was required to indicate only which member of a predesignated pair of elements was present in each display. (H. A. Taylor collaborated in these experiments.) Results from the second method yield estimates of transmitted information significantly larger than those from the first and agree quantitatively with those reported earlier by G. Sperling for a sampling procedure.

Relative to the second question, a simultaneous sampling model, derived from statistical learning theory, can be rejected. A model assuming serial sampling of the display elements with random stopping provides a relatively good account of the data.

When the estimate of the number of elements processed is plotted versus number of elements in the display, the curve yielded by the report procedure levels off beyond 5 to 6 elements while the curve for the detection procedure continues to rise. This disparity poses special problems for theories of retention loss following stimulation and immediate response.

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An Experiment to Determine the Gravitational Force on Free Electrons and Positrons

Although the equivalence between gravitational and inertial mass has been experimentally demonstrated by Eötvos and recently to 1 part in 10^{11} by Dicke, no observation has ever been made on the force of gravity on a charged elementary particle or on antiparticles. Gold and Morrison have suggested in connection with cosmological arguments that the gravitational force between antimatter and real matter might be repulsive. We are attempting to measure directly the gravitational force on a single isolated electron in free fall. It is planned to repeat the experiment with positrons. In measuring the free fall of an electron it is necessary to reduce the effect of the electric and magnetic fields in the direction of the gravitational force to a value below the effect of gravity. In the actual experiment pulses of electrons in the magnetic ground state are guided by a homogeneous vertical magnetic field along the axis of a copper cylinder to an electron multiplier detector. The times of flight of the slowest electrons are observed and the effect of gravity is determined by the distribution of electrons in time. We have reduced the effect of electric and magnetic fields in a 1-inch-diameter copper tube sufficiently to allow the passage of 10^{-11}-ev electrons. Electrons have been observed to take 0.17 second to travel 15 cm, making it appear possible to measure the force of gravity on electrons and positrons. The experimental apparatus can be modified to measure with extreme accuracy the anomalous magnetic moment of a free electron and positron.

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X-ray Emission from Neutron Stars

An instrumented Aerobee rocket has been used to measure fluxes of x-rays arriving from sources in the galaxy, or extragalactic space. Discrete sources were observed in the Scorpius region (α = 16 hours 15 minutes, $\delta = -15°$) and in the direction of the Crab Nebula. The spatial resolution of the collimated proportional counter x-ray detector was 10 degrees so that it was not possible to discriminate between an extended source such as a gas cloud or a star.

Attempts have been made to fit the observations to a neutron star model (H.-Y. Chiu, *Ann. Phys. N.Y.*, in press; D. Morton, *Astrophys. J.*, in press). The flux from Scorpius is consistent with a star of solar mass, 10 km radius,

and core temperatures of 10^8 to 2×10^9 deg K, corresponding to distances from 100 to 1000 parsecs. At these distances the neutron star would be unobservable in the visible spectrum. Cooling times would permit association with a supernova event within the past 1000 years.

The source in the Crab Nebula was one-eighth as bright as the Scorpius source. No emission was detected from Cygnus A, Centaurus A, or Cassiopeia.

H. FRIEDMAN, S. BOWYER
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The Symmetry Group of the Vector and Axial Vector Currents

We apply, with a slight modification, the theory proposed earlier [M. Gell-Mann, *Phys. Rev.* **125**, 1067 (1962)] of a higher broken symmetry than the eightfold way. The integrals of the time components of the vector and axial vector current octets are assumed to generate, under equal time commutation, the algebra of SU(3) × SU(3). The energy density of the strong interactions is assumed to consist of a piece invariant under the algebra, a piece that violates conservation of the axial vector currents only and belongs to the representations (**3**, **3***) and (**3***, **3**), and a piece that violates the eightfold way and belongs to (**1**, **8**) and (**8**, **1**). An attempt is made to assign particles approximately to super-supermultiplets. The pseudoscalar meson octet, together with a pseudoscalar singlet, a scalar octet, and a scalar singlet, may belong to (**3**, **3***) and (**3***, **3**). The vector meson octet, together with an axial vector octet, may belong to (**1**, **8**) and (**8**, **1**). The baryon octet with $J = 1/2^+$, together with a singlet with $J = 1/2^-$, may belong to (**3**, **3***) and (**3***, **3**), as previously suggested (*op. cit.*). Several crude coupling patterns and mass rules emerge, to zeroth or first order in the symmetry violations, and are roughly in agreement with experiment. Work supported in part by the U.S. Atomic Energy Commission.

MURRAY GELL-MANN
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Measurement of Time Correlations in Quantum-Mechanical Systems

Measurements that are of limited accuracy, are incomplete, or which require a finite time do not generally permit one to construct a wave function for describing a physical system. The use of such partial information to predict results of subsequent measurements is studied. Practical applications to effects such as the Hanbury-Brown and Twiss measurement will be described.

M. L. GOLDBERGER
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Target Discrimination by the Echolocation of Bats

Since bats intercept flying insects by echolocation, an ability to discriminate between echoes from edible and inedible targets would clearly be to their advantage. In a laboratory flight room *Myotis lucifugus* first learned to catch nearly every mealworm mechanically tossed into the air, one at a time; then metal or plastic disks of roughly the size of mealworms were substituted in an irregular sequence. At first the bats caught the disks indiscriminately, but after several days some learned to reject all but 10 to 20 percent of the disks without touching them, while continuing to catch 90 to 100 percent of the mealworms. The mealworms were approximately cylinders of 2 to 3 mm by 16 to 28 mm. The disks tested were 0.5 mm by 6.3, 9.5, 12.5, and 15.9 mm, or 3 mm by 12.5, 15.9, and 17.8 mm. The wavelengths of the bats' orientation sounds ranged from about 3 to 15 mm (100 to 25 kcy/sec).

Frequency-modulated sound pulses simulating the orientation sounds of these bats were projected at each of the targets; a microphone adjacent to the loud-speaker, but shielded from the transmitted sound pulse, picked up measurable echoes from all targets in all possible orientations. Echoes from mealworms and disks varied by 20 to 30 db or more, depending on target orientation, and the range of echo intensity for all the disks overlapped extensively with the range of mealworm echoes. This was the case not only for the peak of the echo from a 100- to 20-kcy/sec FM pulse, but also in each 10-kcy/sec band from 100-90 to 30-20 kcy/sec. Some type of "fine structure" in the echoes must thus be used by flying bats to distinguish between small moving objects on the basis of shape or other qualitative properties.

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The Immunologically Specific Capsular Polysaccharides of the Pneumococcal Types XVIII and XVIIIA: Similarities and Differences

As already shown, the type XVIII substance, SXVIII, contains D-galactose, D-glucose, L-rhamnose, α-glycerophosphoric acid as a side chain, and immunologically important *O*-acetyl in the approximate proportions 1:3:1:1:1. SXVIIIA is made up of D-galactose, D-glucose, rhamnose, glycerophosphoric acid and *N*-acetylglucosamine in the approximate ratios 2:3 (or 4):1:1:1. It lacks *O*-acetyl groups and is more resistant to alkaline degradation than SXVIII. The rhamnose and aminosugar were identified chromatographically; the other components, with the help of appropriate enzymes as well. Of the sugars in SXVIIIA, most, if not all, of the D-glucose disappears, as in SXVIII, on oxidation with periodate, while the others appear to be stable. The cross-reactions between the polysaccharides and antipneumococcal XVIII and XVIIIA sera are extensive in both directions.

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Paramagnetic Resonance Absorption by Organic Molecules in Triplet Ground States in Single Crystals

The investigations made by G. L. Closs at the University of Chicago have made it possible to prepare oriented molecules of divalent carbon compounds in single crystals. In such crystals sharp line paramagnetic resonance spectra (characteristic of molecules in triplet states) are observed. The zero-field splittings are extremely large and the anisotropies are correspondingly great. These facts indicate that two electrons with parallel spins exist mainly on a single carbon atom. When the divalent carbon atom in these molecules is a C^{13} atom the resulting hyperfine structure shows the extent to which the two triplet state electrons are localized on this carbon atom. The interrelations between the hyperfine structure and the fine structure have been investigated.

The species which have been examined and which will be discussed are

diphenylmethylene and fluorenylidene. Considerable information has been obtained concerning electron spin distributions, electron delocalization, and molecular and crystal structure in these systems.

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Amino Acid Incorporation into Myelin in Cell-Free Rat Brain Preparations

Amino acid incorporation into protein of the crude "mitochondrial fraction" is more rapid in cell-free preparations from immature rat brain than in similar preparations from mature brain. The rate of amino acid incorporation varies with age in a manner closely resembling that of myelinization observed in vivo. Separation of the cellular fractions by discontinuous gradient centrifugation following incubation of the reaction system containing the precursor C^{14}-amino acid and the crude "mitochondrial fraction" from immature brain results in the recovery of highly labeled material in the fraction containing the myelin, as confirmed by electron microscopy. Larger quantities much lower in specific activity are recovered in this same fraction from mature brain preparations. Proteolipid extracted from the crude "mitochondrial fraction" following incubation is low in quantity but high in specific activity in the case of immature brain and opposite in adult brain preparations. The C^{14}-amino acid is incorporated into the interior of the peptide chain of the proteolipid. The amino acid composition of the recovered proteolipid closely resembles that described for myelin. These results suggest that the crude "mitochondrial fraction" of immature brain incorporates amino acid into polypeptide components of myelin in vitro.

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Specification of Materials for Retarding Water Evaporation—Spreading Hexadecanol Monolayers

Field studies on the control of evaporation by monolayers have progressed to a stage where detailed specifications and treatments of the monolayer-forming material are required. The Columbia University surface pressure–evaporation balance (Evaporimeter), as now operating, is suitable for delineating such specifications. Previous investigations in these laboratories had not included the rate of spreading of the monolayer. Monolayers have been spread by various means and left to approach equilibrium. A time of 200 seconds is sufficient to attain this state. A survey of the spreading rate behavior of the alcohols therefore became necessary in order to utilize fully the resistance-pressure balance as a tool for specifying suitable materials for field work.

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University of California, Berkeley

The Pathway of Gluconeogenesis in Liver

Early experiments by Hastings and his students indicate the necessity of pyruvate being carboxylated to a four-carbon dicarboxylic acid before it is converted to carbohydrate in liver cells. Quantitative measurements of enzymes in liver under the influence of hormones and differing dietary conditions have led to the elucidation of a pathway for gluconeogenesis. Pyruvate is carboxylated to oxalacetate (OAA) in mitochondria and α-ketoglutarate formed from OAA via the tricarboxylic acid cycle is reductively aminated to glutamate, or transaminated with alanine. Glutamate diffuses out of mitochondria and may be transaminated with pyruvate to form α-ketoglutarate and alanine. α-Ketoglutarate may be carboxylated by the isocitric dehydrogenase in the soluble portion of the cell. Citrate formed from isocitrate is cleaved by Srere's enzyme to form acetyl CoA for lipid synthesis and OAA for carbohydrate synthesis via Utter's phosphopyruvic carboxykinase. Malic enzyme does not participate in four-carbon dicarboxylic acid formation but its enhanced synthesis under the influence of insulin or of carbohydrate feeding shunts four-carbon acids to pyruvate and gluconeogenesis is diminished. Glucocorticoids, fasting, feeding diets containing only fat and protein, and diabetes result in enhanced synthesis of phosphopyruvic carboxykinase which favors utilization of OAA for gluconeogenesis.

HENRY A. LARDY, EARL SHRAGO
JERRY W. YOUNG, VERNER PAETKAU
University of Wisconsin

Biosynthesis of the Decapeptide Antibiotic Tyrocidine as Distinguished from Protein Biosynthesis

The successive reactions which guarantee a direct genetic control of specific amino acid sequences in the biosynthesis of proteins have been well studied. However, little is known about the biosynthesis of smaller polypeptide molecules, such as certain hormones and antibiotics.

When protein biosynthesis is compared with the biosynthesis of tyrocidine, a decapeptide antibiotic produced by *B. brevis*, the two processes can be clearly separated. This indicates that a distinct series of reactions, different from those involved in protein biosynthesis, can direct the synthesis of specific polypeptide chains of at least ten amino acids. The amino acid activation process appears to be enzymatically different in the two syntheses; chloramphenicol and puromycin inhibit protein synthesis but not tyrocidine biosynthesis; several compounds which inhibit RNA synthesis, and consequently protein synthesis, have no effect on tyrocidine biosynthesis; the formation of aminoacyl-S-RNA by *B. brevis* cells can be inhibited without affecting the biosynthesis of tyrocidine; finally, newly synthesized tyrocidine and protein appear to be associated with different subcellular constituents.

Three single amino acid substitutions observed in tyrocidine were also studied. These substitutions, unlike those observed in proteins, are determined by the environmental concentrations of the amino acids involved. This type of replacement, which involves structurally related amino acids, implies a low specificity in the enzymatic recognition of these amino acids. These experiments suggest some flexibility in the control of amino acid sequence in small polypeptides. The structural specificity, and consequently the biological activity, of certain polypeptides may thus depend in part upon environmental factors and may not be under absolute genetic control.

BERNARD MACH, E. L. TATUM
Rockefeller Institute

Temporal Sequence of Types in the Evolution of Galaxies

Articles by Lindblad and Schmidt in the recently published proceedings of the IAU symposium on extragalactic

research, and the discussion, underscore the uncertainty whether the evolution of galaxies proceeds from irregulars to spirals to ellipticals or in the opposite direction. The study of morphological types of members of physical pairs of galaxies may contribute to the answer. Assumptions: (i) member galaxies of a pair were formed simultaneously; (ii) each galaxy (perhaps of a specified category) must go through a sequence of identifiable stages, numbered $i=1,2,\cdots,s$, always in the same but unknown order; (iii) the time X_i spent in the ith stage is a random variable; (iv) twin galaxies evolve independently. These assumptions imply that the probability that one member of a pair will have type m and the other type n can be written as

$$\int_0^\infty P\left\{\Sigma_{j=1}^{m-1} X_{1j} < t \leqq \Sigma_{j=1}^{n} X_{1j}\right\} \times P\left\{\Sigma_{k=1}^{n-1} X_{2k} < t \leqq \Sigma_{k=1}^{n} X_{2k}\right\} d\lambda(t)$$

where $\lambda(t)$ stands for the age distribution of pairs of galaxies. A plausible specialization of the above formula leads to a criterion to decide whether, in the evolutionary sequence, a morphological type A precedes another type B. Let n_{ij} denote the number of pairs of galaxies per unit volume with one member of type i and the other of type j. Then type A precedes type B if

$$C(\mathrm{A}) = \Sigma_j\left(\frac{n_{Aj}}{\Sigma_k n_{Ak}}\right)^2 > \Sigma_j\left(\frac{n_{Bj}}{\Sigma_k n_{Bk}}\right)^2 \equiv C(\mathrm{B}).$$

JERZY NEYMAN
University of California, Berkeley

Fundamental Chromosome Structure

An interpretation of fundamental chromosome structure will be presented which explains the loops of lampbrush chromosomes as due to the unwinding of a gene complex and not to the uncoiling of a chromatid and, thus, does not require that we think of an uncoiled chromatid in terms of centimeters or even of meters of length. It also largely does away with the current concept of the cable-like or high polytene structure of mitotic chromosomes.

It is believed that the backbone, or axis, of a chromosome is largely protein, with possibly an admixture of low molecular weight and nongenetic DNA, and that gene complexes are attached as side loops or branches similar to the cyclical "chromosomes" of microorganisms. Visible chromomeres are compound and consist of a number of gene loci, and when one of these becomes activated it uncoils and a visible loop is formed with an axis of DNA, some mRNA, and protein synthesized at the site.

Electron photographs of chromosomes, when not cut through the axis of a chromosome, show a mass of vermicelli-like tubules which many have misinterpreted as parts of chromatids. It is suggested that these tubules are coiled gene complexes. When the section passes through the axis of a chromosome the protein backbone is clear enough and the coiled tubules are attached along the side, as Nebel has pointed out.

THEOPHILUS S. PAINTER
University of Texas

The Rectangularity Law of Transformers

The geometry of a transformer is completely specified by the windows of the iron core and the copper coil. The optimal dimensions of these windows are determined by many factors, such as desired kva rating, acceptable losses, cost of iron, cost of copper, and so forth. In spite of these many factors influencing design, we have been able to deduce, from topological arguments alone, a simple relation between the rectangularity of the iron and copper windows for optimum geometrical design. The type of topological argument used has general applicability to the optimum design of other types of equipment.

E. L. PETERSON, C. ZENER
Westinghouse Research Laboratories

The Entrainment of Circadian Oscillations by Skeleton Photoperiods

There is still no general quantitative theory for the entrainment of circadian oscillations in living systems by light cycles. Recent work has established: (i) that the phase of the entrained steady-state is a sensitive function of photoperiod; and (ii) that the action of nearly all photoperiods (for example, 8 or 12 hours of light per cycle) can be simulated by short (15-minute) pulses marking the beginning and the end of the period. This phenomenon of entrainment by "skeleton photoperiods" has opened up new approaches to the analysis of entrainment in general. A model is presented that gives a complete, quantitatively adequate, description of entrainment based on the known response of circadian oscillations to single perturbations. It is noted that this model has considerable bearing on the interpretation of many experimental procedures applied to the analysis of classical photoperiodism.

COLIN S. PITTENDRIGH
Princeton University

Phasing, Mitotic Delay, and Chromosomal Aberrations in Mammalian Cells

The method for life cycle analysis previously described [Puck and Steffen, *Biophys. J.* **3** (5), 379 (1963)] was applied to determine whether an excess of thymidine affects all stages of DNA synthesis or only its initiation. Experiments demonstrated the former to be the mechanism involved. Since 26 percent of a random population of S3 HeLa cells is distributed throughout the entire length of the DNA synthesis region, S, no agent which stops all S cells can produce a strongly phased culture. However, by applying an agent like thymidine for a period long enough to accumulate all cells in S, then relieving the block long enough for all cells to finish S, and finally re-adding $2.5 \times 10^{-3} M$ thymidine, the cells are all accumulated in a sharply defined interval at the beginning of S. By means of this principle, large populations can be obtained which contain 98 percent of their cells within a region no larger than 5 percent of the total life cycle. High concentrations of bromuracil, a thymine analog which is also incorporated in DNA, behave like an excess of thymidine in inhibiting DNA synthesis.

Study of the action of streptonigrin, an agent known to produce chromosome breaks, was undertaken in order to test the theory proposed previously that the reversible lag of x-irradiated cells in the G2 region of the life cycle is a result of chromosomal breaks induced by the radiation. Experiment demonstrated that streptonigrin does not affect cells in which DNA synthesis was completed before its addition, nor does it inhibit G1 or DNA synthesis. However, the cells in which DNA replicates in the presence of streptonigrin

exhibit chromosome abnormalities, and a large delay in reaching mitosis which is similar to that produced by x-irradiation.

THEODORE T. PUCK
University of Colorado Medical Center

Integrated Magnetic and Superconductive Computer Memories

Electronic storage of the program for processing data as well as the data itself has given modern computers the versatile manipulative power which allows these machines to be applied equally to the handling of any routine on masses of data and the execution of most elaborate chains of computations. Clearly, the storage capacity and the speed of access of its internal memory will determine the capability of the computer. Present memories consist of arrays of magnetic cores addressed by transistors and have typically reached capacities of 1,000,000 bits and access times of 1 μsec. Further improvement requires a radical change. Instead of assembling individually made elements, an integrated construction must be found for making millions of tiny storing elements and the necessary addressing switches in a single step. We have recently made two advances in memory integration: the laminated ferrite with integrated semiconductor circuits and the superconductive continuous sheet memory.

The laminated ferrite memory consists of a block of ferrite with embedded conductors and is made by a few simple steps. A slurry of ferrite is evenly spread by a "doctor blade" over a glass sheet previously coated with conducting lines. The sheet is peeled off. Three or more sheets are pressed together and then are sintered. The result is a thin (0.005-inch) structure of ferrite containing closely spaced (0.005- to 0.010-inch) conductors which form at their intersection tiny (equivalent diameter 0.003 inch) storing elements. Sheets with 16,384 elements have been made. The smallness of the elements permits high-speed operation (access times of 0.1 μsec have been obtained) or the use of very low drive currents (typically 30 to 50 ma or ten times less than necessary for standard cores). The low current and the compactness of the magnetic structure makes possible the use of integrated semiconductor addressing and sensing circuits. Particularly promising are integrated metal-oxide-semiconductor field effect transistors. The combination of integrated ferrites with integrated transistors promises to make economically feasible capacities of tens to hundreds of millions of bits.

Superconducting offers ideal properties for memories: persistent currents for storage, fast and controllable transition from superconductive to normal states for switching, and diamagnetism for perfect magnetic shielding. Moreover, the technology of thin superconductive films permits the simultaneous integrated fabrication of the storing elements, addressing switches, and all connections. A continuous sheet of tin is the site of the storing of persistent currents which are induced in it at the intersection of closely spaced (typically 0.005 to 0.010 inch) superimposed lead x and y lines. The x and y lines are selected by switching cryotrons arranged in trees. The state of the interrogated element is sensed by a signal induced in a simple box-like cavity beneath the memory plane. Planes with 16,384 elements have been operated. The seemingly esoteric superconductive technique is likely to be the first and possibly the only to furnish electronic memories with capacities of billions of bits with access time of a fraction of a few microseconds. Such capacities are available today only in electromechanical memories with access time of a fraction of a second.

JAN A. RAJCHMAN
RCA Laboratories

Volatile Organic Matter of Plant Origin in the Atmosphere

Using a sensitive gas chromatograph mounted in a mobile trailer laboratory, the presence in air of many organic compounds in molecularly disperse state can easily be measured. The hydrogen flame detector, which responds only to organic molecules, has a sensitivity of better than $1:10^9$, using 5-cc air samples.

Whereas in cities gasoline and other man-produced organic vapors constitute the bulk of the organic volatiles in the air, in the countryside, away from highways and human activities, plant products predominate. Among these, α- and β- pinene, myrcene, and isoprene were identified. Their concentration depends on meteorological conditions, and density and activity of plant cover; during summer usually more than 10^{-8} organic volatiles occur in country or forest air; during winter this decreases to 2×10^{-9}. After one or more dark rainy days plants release less terpene. Upon the death of cells large amounts of terpenes are released, explaining the aromaticity of drying hay or of forests during autumn. High concentrations of terpenes in the air were associated with the dying of leaves in autumn, and with the mowing of meadows.

REINHOLD RASMUSSEN, F. W. WENT
Washington University

Studies on the Biosynthesis of Tobacco Mosaic Virus

The mode of synthesis of tobacco mosaic virus (TMV) within a cell is not understood either with regard to mechanism or site of its formation. Its formation in the cell involves the synthesis of considerable amounts of RNA and protein. Since the site of synthesis of most of the cell proteins is recognized as being the microsomes of the cytoplasm, it is of interest to study the effect of infection on these particles.

Following infection with TMV the microsomal RNA of the cytoplasmic fraction of the tobacco leaf cell is rapidly degraded and its ribonucleoside moieties are utilized in the synthesis of TMV-RNA. The amount of TMV-RNA synthesized is approximately equal to the amount of microsomal RNA degraded.

An examination of the microsomes of the cytoplasmic fraction of the infected tobacco leaf cell showed that these particles are free from an RNA template resembling the composition of TMV-RNA. It is concluded that in vivo the microsomes of the cytoplasmic fraction are not the site for the formation of virus-induced proteins.

The examination of the nuclei isolated from the infected tobacco leaf revealed the presence of a nucleoprotein which is resistant to chloroform-octanol treatment and digestion with pancreatic ribonuclease. It is sedimentable at 105,000g and is infectious. Its nucleotide composition is guanylic acid, 1.00; adenylic acid, 1.15; cytidylic acid, 0.73; and uridylic acid, 1.04. Electron microscopic examination revealed particles resembling TMV. From these results it is tentatively concluded that TMV is synthesized in the nucleus.

K. K. REDDI
New York University School of Medicine

Electrical Responses of the Human Eye to Moving Stimulus Patterns

The observer fixates on a point at the center of a grating test pattern composed of alternate light and dark stripes. The grating is then oscillated laterally with an excursion of one stripe width, an amount approximately equivalent to 1° of visual angle. The effect is that each point on the retina is alternately exposed to light and darkness while the total light flux remains constant. A contact lens electrode and response-averaging computer are used to record the resulting electrical responses of the retina.

When the test pattern consists of high-intensity monochromatic light, the response amplitude rises from zero at equal stripe luminances (homogeneous field) to a maximum value as one set of stripes is progressively reduced to zero luminance (maximum contrast). A moderate degree of contrast may be chosen to yield a conveniently measurable amplitude of response. A spectral sensitivity function is found by determining the energy at each wavelength necessary to produce a response of this criterion amplitude. The function is in close agreement with psychophysical determinations of the photopic spectral sensitivity of the same observer.

Of greatest interest are experiments in which stripes of one wavelength alternate with stripes of another. When such stripes are equated for luminance there is a greater and greater response as the difference in wavelength increases. With wavelength differences approaching those of complementary hues the resulting responses are indeed larger than those produced by the maximum contrast situation in which stripes of a single wavelength alternate with black.

LORRIN A. RIGGS, E. PARKER JOHNSON
AMY M. L. SCHICK
Brown University

Evidence for the Existence of a Large-Scale Magnetic Field and for High-Energy Electrons in the Exploding Galaxy M82

C. R. Lynds showed in 1961 that the nearby galaxy M82 emits radio radiation. Direct photographs obtained with the 200-inch Hale telescope in 1962 suggested that an explosion took place in the center of this galaxy about 1.5×10^6 years ago. The radio noise is presumably generated by high-energy electrons accelerated by a magnetic field, thereby producing synchrotron emission. Partial evidence was obtained in 1962 that the frequency of the synchrotron radiation extends from 10^8 cy/sec in the radio region to greater than 10^{15} cy/sec in the optical range.

New photographs, also taken with the Palomar telescope, give more complete evidence for the existence of optical synchrotron radiation. A large-scale system of filamentary structures which extend to distances of 13,000 light years (4000 parsecs) above and below the plane of M82 has been photographed. Three tests suggest that the filaments do indeed radiate by the synchrotron process: (i) The light is continuum radiation rather than line emission. (ii) It is nearly 100 percent linearly polarized with the electric vector perpendicular to the main filamentary structures. (iii) The photoelectrically measured color indices of segments of the filaments are $B-V = 0.48$, $U-B = -0.41$, which are close to the predicted values for synchrotron emission computed for the conditions in M82.

The polarization test is the most stringent of the three, and agreement of observation and theory is taken as evidence of a rather uniform large-scale magnetic field in M82 directed along the minor axis of the galaxy. Calculation of the energetics [Lynds and Sandage, *Astrophys. J.* **137**, 1005 (1963)] shows that the field strength may lie between 10^{-5} and 10^{-6} gauss. Electrons with energies as high as 1000 Bev must then be present in the halo of M82 to produce the optical synchrotron emission. The average energy density of the electrons is 1000 ev/cm^3, which is 1000 times higher than that due to the proton component of cosmic rays in the solar neighborhood of our galaxy.

ALLAN SANDAGE
Mount Wilson and Palomar Observatories

Countercurrent Heat Exchange in the Respiratory Passages

The desert rodents known as kangaroo rats normally subsist on dry food without any drinking water. Water formed in the oxidation of foods suffices to cover losses through evaporation, urine, and feces. The evaporation from the respiratory tract in these rodents is less than what corresponds to the water content of expired air saturated at body temperature. The low evaporation could be explained if the expired air were (i) not completely saturated, or (ii) colder than body temperature. Measurements show the latter to be true. At 25°C room temperature the temperature of expired air and nasal passage walls approach and may even be lower than 25°C, although body temperature is 38°C.

The low temperatures are readily explained if the nasal passageway is regarded as a counter-current heat exchanger. The ordinary heat exchanger, as employed in industry and as described for various biological systems, has two streams of fluid moving continuously in opposite directions; the nasal passage, on the other hand, has only one conduit where air flows intermittently in alternate directions. During inspiration the nasal walls are cooled by incoming air, and additional heat is removed by evaporation. During the following expiration heat flows from the warm air to the cool surfaces. In man this type of heat exchange is of minor importance because of the larger dimensions of the passageways which preclude temperature equilibrium between the core of the air stream and walls. Supported by grants from the National Institutes of Health.

KNUT SCHMIDT-NIELSEN
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Duke University

Killer Particles and Metagons of Paramecium Grown in Didinium

The killer symbiotic particles, kappa and mu, heretofore known to exist and multiply only in *Paramecium aurelia* containing the genes *K* and *M*, respectively, were introduced into another ciliated protozoan, *Didinium*, by feeding them killer paramecia. Once introduced, the particles continued to multiply and persist indefinitely in the new host, even when its diet was shifted to nonkiller paramecia lacking the killer particles and killer gene. Of four stocks of *D. nasutum* tested, one behaved as stated, one could maintain kappa only about 65 cell generations and then died, and two failed to maintain kappa or mu. An RNA intermediate, the metagon, is known to be

present in *M* paramecia in which it has little or no capacity to multiply, disappearing irreversibly several fissions after change of genotype from *M* to *m*. The maintenance and reproduction of μ in paramecia depend on the presence of one or more metagons. Extracts of μ-bearing didinia, obtained as above, also possess metagon activity. The metagon can be introduced into didinia by feeding them initially *M* paramecia lacking mu; it is found to be present in the progeny after 6 months (about 1000 cell generations) of feeding on metagon-free (and mu-free) *m* paramecia. Thus, although metagon reproduction may be either very slow or non-existent in paramecia, it occurs, and rapidly, in didinia. The metagon can grow like this even in a strain of *Didinium* that cannot maintain mu or kappa. Didinia which had never been fed paramecia bearing metagons or mu or kappa possess none of these.

Supported by grant, American Cancer F-81F, to T. M. Sonneborn. Ian Gibson: USPHS Genetics Training Grant Post-doctoral Fellow.

T. M. SONNEBORN
IAN GIBSON, MYRTLE V. SCHNELLER
Indiana University

Enhancement of Antibody Formation by X-Radiation

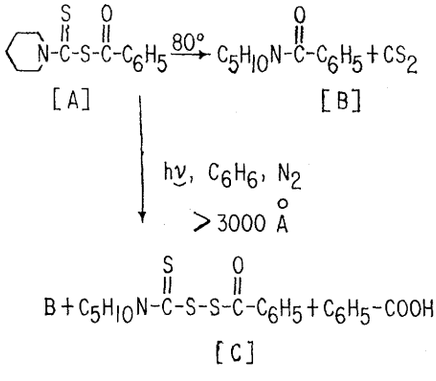
Two types of radiation-induced enhancement of hemolysin formation have been found in rabbits injected with the antigen, sheep red blood cells. Type 1 exhibits a true stimulatory effect in that increased amounts of hemolysin are formed at abnormally high rates. It occurs under the following conditions: (i) when antigen is injected 2 days to 2 hours before relatively small doses (25 to 300 r) of total-body radiation, (ii) when antigen is injected 2 days after the local administration of 2000 to 10,000 r to the exteriorized spleen while the rest of the body is shielded, and (iii) when antigen is injected 1 or 2 months after 25 to 300 r during recovery from x-ray damage. Type 2 is apparently the result of an injured synthetic mechanism that operates over an extended time in that increased amounts of hemolysin are formed at significantly reduced rates. It is found when antigen is injected 2 days to 2 hours before relatively large doses (500 to 700 r) of total-body irradiation.

These irradiation effects will be discussed in relation to the following possible mechanisms, which have been advanced by various authors: the adjuvant action of nucleic acid derivatives liberated by the cytotoxic action of x-rays, the selective repopulation of irradiation-depleted lymphatic tissue by induced rather than noninduced cells, reparative overcompensation and, in the case of partial shielding, the preservation and movement of induced or inducible cells. (This work was supported by U.S. Atomic Energy Commission.)

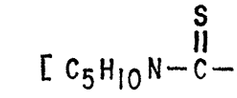
WILLIAM H. TALIAFERRO
LUCY GRAVES TALIAFERRO
Argonne National Laboratory

Photochemical and Thermal Transformations of Carboxylic Dithiocarbamic Anhydrides and Related Compounds

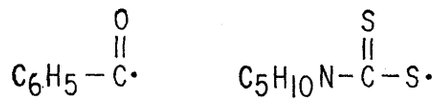
The thermal decomposition of carboxylic dithiocarbamic anhydride [A] gives amide [B] and CS_2 [Tarbell and Scharrer, *J. Org. Chem.* **27**, 1972 (1962)]. Photolysis of [A] under nitrogen gives amide (74 percent), benzoic acid (9 percent), and the unusual acyl thiocarbamyl disulfide [C] (34 percent).



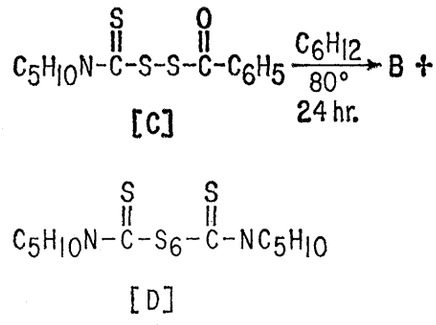
Photolysis of [A] in the presence of oxygen yields in addition about 6 percent of the thiuram disulfide,



The most reasonable pathway for this photolysis involves formation of the radicals



Compound [C] is photolyzed slowly to the amide [B]. Thermal decomposition of [C] in refluxing cyclohexane yields amide and the polysulfide [D] as the only isolable products.



Experiments dealing with the mechanisms of these transformations and the evidence for the structures will be presented.

D. STANLEY TARBELL
ELAINE H. HOFFMEISTER
University of Rochester

A Suggested Mechanism for the Excessive Production of Type I and III Porphyrins in Erythropoietic Porphyria

The genetic error in erythropoietic porphyria has been postulated as a deficiency of isomerase, which directs formation of type-III porphyrins. The present results reveal, however, that these, including protoporphyrin 9, are formed in considerable excess both in vivo and in vitro, the latter either with human or bovine porphyric hemolysates incubated with porphobilinogen or (Heilmeyer *et al.*, 1963) with δ-aminolevulinic acid (ALA). The excessive formation in vivo is represented chiefly by the characteristic increase of fecal urobilinogen, but also by significant amounts of type III excreted with the preponderant type-I porphyrins, the latter owing their formation to the deaminase alone. Since the hemoglobin protoporphyrin is entirely type 9, the urobilinogen may also be assumed to be entirely 9α. The specificity of coproporphyrinogenase for copro-III excludes conversion of uro- and copro-I to a corresponding protoporphyrin, heme, and bile pigment.

The excessive isomerase and deaminase activity thus evident suggests a genetic deficiency of the repressor in the operon responsible for the normally balanced induction of these enzymes.

This accords well with the above observations assuming some imbalance favoring deaminase, thus promoting formation of type-I porphyrins. This might be related to the locus of its structural gene in respect to that for isomerase. Alternatively, the same effect might be produced by an abnormality of the regulator gene for this operon.

In vivo, a secondary increase in total ALA synthetase activity may be assumed, analogous to that which occurs with any increase of hemoglobin synthesis. Aided by grants from USPHS.

C. J. WATSON
IRENE BOSSENMAIER
RUTH CARDINAL
University of Minnesota

The Nature of Aitken Condensation Nuclei in the Atmosphere

In addition to microscopically visible particles there are far more numerous submicroscopic particles in the atmosphere on which supersaturated water vapor can condense. A number of inorganic compounds—predominantly sodium chloride and ammonium sulfate—have been identified among these condensation nuclei, but the bulk of them are chemically unidentified. The suggestion was made that many of these Aitken nuclei were organic in nature and originated from volatile substances produced by land plants.

It can now be reported that:

1) α-pinene, a principal volatile plant product, produces condensation nuclei, both in the laboratory and in nature, if its vapor is subjected to high light intensities in the presence of catalysts such as nitrogen oxides or iodine vapor;

2) The quantity of plant volatiles suffices to account for the quantity of Aitken nuclei;

3) The organic nature of at least part of the Aitken nuclei has been established. Measurement of condensation nuclei in the atmosphere suggests that entrapment by larger nuclei is the major mechanism by which the smaller nuclei disappear, and that cumulus clouds play a major role in sweeping the atmosphere clean of such nuclei. They can then be removed by precipitation.

F. W. WENT
Washington University

Geometrical Topics on Reaction Theory

The connection between relativistic kinematics and non-Euclidean geometry is used to illustrate certain properties of collisions between particles. In particular, the connection between reactions in "crossed-channels" is connected in a very simple manner to a rotation of the axes to which the spin directions of the initial and final particles are referred. Work performed under the auspices of the U.S. Atomic Energy Commission.

G. C. WICK
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Brookhaven National Laboratory

Phosphorylation of 2-keto-3-deoxy-galactonic Acid in Galactose Metabolism of Pseudomonas saccharophila

The pathway of galactose metabolism in *P. saccharophila* postulated by DeLey and Doudoroff in 1957 [*J. Biol. Chem.* **227**, 745 (1957)] has been finally confirmed by the isolation of an inducible kinase which phosphorylates 2-keto-3-deoxy-galactonic acid (KDGal) to its 6-phospho derivative (KDPGal). KDPGal was assayed with a specific aldolase from the same organism (M. Doudoroff and C. W. Shuster, *Bact. Proc.*, **1962**, 112).

The KDPGal kinase was purified approximately 80-fold and separated from the aldolase by treating cell-free extracts with acetate buffer at *p*H 5.2, fractionating the supernatant fluid with 40 to 60 percent saturated ammonium sulfate and subjecting the fraction to successive gradient elutions from DEAE and hydroxylapatite columns.

Beside KDPGal, metasaccharinic (3-deoxy-galactonic) acid is a substrate for the enzyme, but neither galactonic nor 2-keto-3-deoxy gluconic acid is attacked. At *p*H 8.0, the K_M values for KDGal and ATP are $7.8 \times 10^{-6} M$ and $2.6 \times 10^{-6} M$, respectively. The magnesium requirement can be satisfied by $0.01 M$ magnesium-EDTA chelate.

With the purified enzyme, KDPGal has been prepared and isolated as the barium salt. The best preparations were 80 to 90 percent pure as calculated for the anhydrous barium salt. The analysis of one such preparation gave the following assays per milligram: total phosphorus, 1.83 μmole; total α-keto acid, 1.96 μmole; pyruvate and D-glyceraldehyde-3-phosphate liberated upon cleavage with KDPGal aldolase, 1.91 and 1.8 μmole, respectively. This work was supported by NIH and NSF grants.

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University of California, Berkeley

Photoperiodic Control of Pupal Diapause in the Silkworm, Antheraea pernyi

Like so many plants and animals, the Chinese oak silkworm is sensitive to the length of the day and night. Days longer than 14 hours cause the silkworm to develop without any interruption in its life history. By contrast, days shorter than 14 hours provoke the onset of a prolonged period of dormancy (diapause) after the silkworm has spun its cocoon and pupated.

The termination of pupal diapause, as signaled by the resumption of development, is likewise controlled by photoperiod. Light penetrates the cocoon and the pupal cuticle and acts directly on the brain. The photoperiod controls the secretion of the "brain hormone" which, in turn, is prerequisite for the resumption of development.

Days longer than 14 hours are required for the secretion of brain hormone and the prompt termination of pupal diapause. Under experimental conditions at 25°C, a daily photophase of 17 hours provides the maximal stimulus for brain function. Days shorter than 14 hours prevent the secretion of brain hormone and cause a continuation of diapause; the brain is most strongly inhibited by a 12-hour photophase.

At the latitude of Boston, days longer than 14 hours occur from 30 April to 12 August (neglecting twilight). So, at any time during this period, diapause is either prevented or caused to terminate. After 12 August all larvae are forced to diapause and the dormant state is then stabilized until 30 April of the following spring.

Larvae are extremely sensitive to dim light and some modification of these calculations may be required to take account of twilight. However, it seems unlikely that twilight is sufficiently intense to penetrate the cocoon and act on the pupal brain.

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