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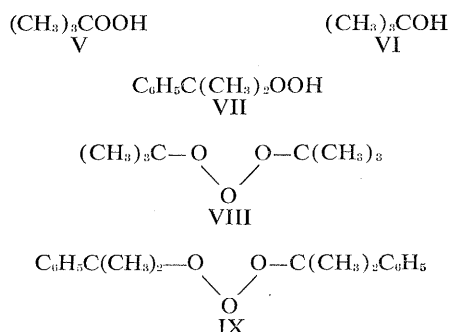
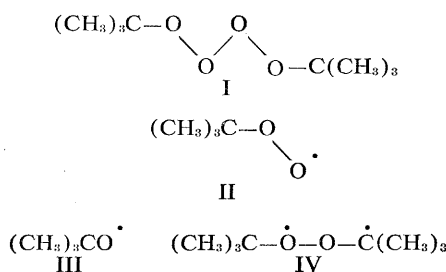
Abstracts of Papers Presented at the Annual Meeting, Washington, D.C., 25–27 April 1966

Role of Tetroxides and Trioxides in the Oxidation of Tertiary Butyl and Cumyl Hydroperoxides

The rates and products of the reaction between free oxygen and hydrocarbons in the liquid phase are best accounted for if an intermediate such as di-tertiary-butyl tetroxide (I) is formed rapidly and reversibly from two peroxy radicals (II) and eventually decomposes by extrusion of its central O_2 to yield two alkoxy radicals (III) which may combine to the stable dialkyl peroxide (IV) before they can diffuse apart. Because there is a rapid hydrogen transfer to III from any hydroperoxide (V) to form new peroxy radicals, a chain reaction exists in which V is converted by free radicals into oxygen and alcohol (VI).

The terminating steps in this reaction, initiated by metallic ions, are identical with those in oxidation of the corresponding hydrocarbons.

At ordinary temperatures the peroxide IV is the only termination product of these chains. It has now been found that an additional termination step occurs when tertiary butyl hydroperoxide (V) or cumyl hydroperoxide (VII) is oxidized with lead tetraacetate in methylene chloride solution below -70°C . When the reaction product is warmed to -30°C further oxygen is evolved, and the chain decomposition of V or VII is re-initiated. The unstable termination product is identified as a trioxide (VIII or IX) formed from coupling of II and III in the tertiary butyl case, and undergoing thermal cleavage at a measurable rate above -35°C .



PAUL D. BARTLETT
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On the Greatest Characteristic Root of a Non-Negative Matrix

For many applications in the natural sciences it is necessary to find bounds for the characteristic roots of a matrix. Perron (1) proved that a positive matrix has a positive root which is greater than the absolute value of the other roots. Frobenius (2) extended Perron's results and generalized them to include non-negative matrices. Since then a number of different proofs have been published for these important theorems.

A few years ago, I gave a new simple proof in the case of positive matrices (3). Not only the existence of a greatest positive root is proved, but the proof gives a method to compute this root as exactly as needed. But there seemed to be no simple proof for the convergence of the method for non-negative matrices. For this purpose, I extended Frobenius' theorems to so-called power-positive matrices (4) and used them for non-negative matrices (5). But, unfortunately, this extended method required the computation of a high power of the given matrix. Now I have found a simple proof for the convergence of my original method for positive and non-negative matrices.

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Discrete Cosmic X-ray Sources, Galactic and Extragalactic

A survey of the sky for x-ray sources was made from an Aerobee rocket in April 1965. The total number of sources identified approximately doubles the previous list. Within a pointing uncertainty of 1.5 degrees, x-rays were detected from the directions of Cas A, Cyg A, and M-87. The luminosities were about 4×10^{36} erg/sec, 2.5×10^{46} erg/sec, and 3×10^{43} erg/sec, respectively. These x-ray powers are one to two orders of magnitude greater than the radio powers.

Cyg XR-1 was only one-fourth as bright in April 1965 as when previously surveyed in June 1964.

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Control of the "Transitional Conformation" of Ferrimyoglobin Crystals

The reactivity of suspensions of ferrimyoglobin crystals ($\sim 2 \mu$ in size) towards various ligands can readily be studied by the dual wavelength method and compared with the reactivity of the dissolved hemoprotein in 75 percent ammonium sulfate. The reactivity towards N_3^- , at pH 6.0 is decreased 20-fold by crystallization [Chance and Ravilly, *Science* **150**, 370 (1965)] and is currently attributed to a smaller probability of the appropriate "transitional conformation" in the crystalline material; in detail, to greater steric difficulty for the distal histidine (E7) to rotate about the $\text{C}_\alpha\text{-C}_\beta$ bond and to allow release from the Fe^{3+} of H_2O and the entry and binding of the N_3^- (Chance and Ravilly, *J. Mol. Biol.*, in press). Kinetic studies of the reaction of crystalline ferrimyoglobin with various ligands (N_3^- , CN^- , F^- , and CH_3OOH) shows an abrupt decrease of reactivity as the pH rises from 8.0 to 9.0 and

OH^- binds the heme. A related decrease is observed in the more rapid reactions of the dissolved protein in 80 percent $(\text{NH}_4)_2\text{SO}_4$ but the decrease is not marked in 0.1M phosphate buffer. These results call especial attention to the possibility that the sulfate attached to the distal histidine is a more important determinant of reactivity in OH^- than in the H_2O compound. A two-dimensional Fourier difference synthesis of the ferrimyoglobin-ferrimyoglobin-hydroxide structures indicates a retention and a significant movement of the sulfate ion towards the heme. It is proposed that the new position of the sulfate further decreases the probability of rotation of the distal histidine and of the achievement of the transitional conformation required for the replacement of OH^- by other ligands. Details of the structures of the OH^- , CN^- , and F^- compounds will be discussed in relation to their reactivities.

BRITTON CHANCE

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Review of Recent Work in the Determination of the Fundamental Physical Constants

The determination of the numerical values of the fundamental physical constants has occupied the efforts of many scientists over the last 50 years. The accuracy with which these values have been determined has shown continuous improvement. Discrepancies in the numerical values have successively been resolved by corrections or improvements in theory. The current status of our information concerning numerical values of the constants is reviewed and analyzed, and several new experiments which have promise of yielding improved accuracy are described.

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The Phloem at the Source of Photosynthates—in Minor Veins of Leaves

In the system concerned with translocation of organic substances the minor veins of leaves are of particular interest because, according to the ac-

cepted concept, the newly synthesized photosynthates enter the system through these veins. Elsewhere in the system the conducting cells, the sieve elements, are characterized by highly specialized protoplasts and appear to form functional units with associated, less-specialized parenchyma cells. The combinations of sieve elements and parenchyma cells extend into the smallest veins but here the parenchyma cells are the dominant elements with regard to number and size. The sieve elements show the usual features of these cells, including lack of nuclei and tonoplasts. The associated cells have complete protoplasts and a strikingly high content of ribosomes. These cells are located between the sieve elements and the mesophyll, that is, in a position appropriate for cells concerned with conduction of materials from the mesophyll to the specialized conduit. In *Cucurbita* leaves the walls of the conducting parenchyma cells are exceptionally rich in plasmodesmata. This feature is not constant for these cells, however, for in *Beta* and *Nicotiana* plasmodesmata are sparse in the vein parenchyma.

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New Cyclic Process for Carbon Assimilation by a Photosynthetic Bacterium

The view is widely held that carbon assimilation by photosynthetic and autotrophic cells must be a cyclic process that continuously regenerates an acceptor for carbon dioxide. Until now, the only known cyclic pathway for the assimilation of CO_2 has been the reductive pentose phosphate cycle, in which a pentose sugar, ribulose diphosphate, is the sole acceptor for carbon dioxide. One complete turn of this cycle incorporates one molecule of CO_2 , regenerates ribulose diphosphate, and yields, on balance, a net synthesis of 1/6 molecule of glucose.

We have now obtained evidence for a new cyclic process for the reductive assimilation of carbon dioxide by the photosynthetic bacterium, *Chlorobium thiosulfatophilum*. One complete turn of the new cycle, which we will call the reductive carboxylic acid cycle, incorporates four molecules of CO_2 and results in the net synthesis of oxalacetate, a four-carbon dicarboxylic acid,

which is itself an intermediate in the cycle. Thus, beginning with one molecule of oxalacetate, one complete turn of the reductive carboxylic acid cycle will regenerate it and yield a second molecule of oxalacetate, synthesized *de novo* from four molecules of CO_2 . Oxalacetate may then be further metabolized through the cycle to provide 2, 3, 4, 5, or 6 carbon compounds for the synthesis of amino acids, lipids, or other cell constituents.

The four steps by which CO_2 enters the reductive carboxylic acid cycle include pyruvate synthase and α -ketoglutarate synthase, two new primary reactions for CO_2 fixation which we have recently described and which require reduced ferredoxin for a reductant, and two well-known enzymic reactions, isocitrate dehydrogenase and phosphoenolpyruvate carboxylase. Evidence will be presented that cell extracts of *C. thiosulfatophilum* contain these and all the other enzymes of the reductive carboxylic acid cycle.

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Observations on Antibrain Antibodies

Since Delezenne first described preparation of antibodies to brain tissues in 1900, many similar experiments have been performed. Various such antibodies have been reported to prevent development of nervous tissue in embryos, to produce demyelination of axons in adults as well as in tissue cultures, to abolish electrical activity of brain and of single axons, and to alter animal behavior. Antibodies to brain tissues seem therefore to show considerable promise as specific tools in the analysis of a wide range of normal and abnormal brain processes.

This paper will outline the program of antibrain antibody production and testing which has engaged us for several years. Antibodies have been prepared against whole brain, brain regions, protein fractions from brain, and pure strains of cultured cells. Emphasis will be placed on certain experiments in which a particular strain of human glial cells serially transplanted in tissue cultures since 1948 successfully evoked a strong antibody response from rabbits; physiological measurements demonstrate at least two antibodies in the

antiserum, one of which displays activity against a variety of non-neural human tissues, while another seems to be specifically antiglial. In these studies, which are still in progress, the response of neurons to the antiglial antiserums has not yet been evaluated.

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Studies of Elemental Abundances in Old Stars

The oldest stars in the galactic halo belong to an extreme galactic population with high space velocities and inclined and eccentric orbits. They reveal the composition of the interstellar gas during the first billion years of star formation in our galaxy. Their chemical composition is one in which elements heavier than oxygen have relative abundances similar to those in the sun, but with total abundances compared to hydrogen reduced by factors from 10 to 200.

Our work is now aimed at the lighter chemical elements. The abundance of oxygen is now being determined in a group of solar-type giants and dwarfs of both populations. A group of collaborators (Conti, Greenstein, Spinrad, and Wallerstein) find the forbidden absorption line of neutral oxygen strongest in high-velocity red giants. Combined with molecular equilibria and stellar opacity theory, this observation results in the startling indication that the ratio of oxygen to hydrogen has nearly the normal solar value in old stars, which have a metal deficiency of a factor of ten or more.

Relative to the primeval abundance of helium to hydrogen, we can turn to the "horizontal-branch" blue stars. The helium abundances can only be studied in hot stars, but the hot main-sequence stars of the old population have disappeared. Fortunately, in an advanced stage of evolution, stars briefly populate a hot sequence in globular clusters. They are very faint and can only be studied at low resolution; some were found by Münch to have only weak helium lines. Similar brighter objects in

the halo of our galaxy have now been found in my study of faint blue stars, with temperatures high enough to show helium lines. These stars are also marked by a surprising weakness of helium. The abundance ratio of helium to hydrogen is greatly reduced. If the primeval ratio of helium to hydrogen proves much lower than 35 percent it will be difficult to understand explosive cosmologies.

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Hydrolytic Weakening of Quartz Crystals

Quartz single crystals deformed in compression under high confining pressure are reduced in strength by a factor of ten or more above a critical temperature which depends on their water content as inferred from 3-micron infrared absorption. In a suite of 12 natural and synthetic crystals, this critical temperature of weakening varies from 380°C with 0.13 percent (by weight) water ($9000 \text{ H}/10^6 \text{ Si}$) to 1070°C with 0.0015 percent ($100 \text{ H}/10^6 \text{ Si}$). This thermally activated weakening process is reversible with temperature and is strain-rate dependent. The mechanism of deformation is intracrystalline glide both above and below the weakening temperature, but the plane of easiest glide is basal below and apparently prismatic above the critical temperature.

Transmission electron microscopy reveals three predominant types of structures at low, intermediate, and high temperatures. Basal faults predominate at low temperature. At higher temperatures, but below the critical temperature of weakening, straight dislocations lying in the basal plane parallel to a axes predominate. Preliminary results indicate that the most common Burgers vector is parallel to another a axis which has the maximum resolved shear stress in the basal plane. Above the critical temperature, curved dislocations predominate. Dislocation densities in both cases are about $10^9/\text{cm}^2$.

Annealing of crystals with high water content which have been deformed above the critical temperature reduces the dislocation density and causes the formation of water bubbles. Thus, there is an apparent $\text{Si-OH}\cdot\text{HO-Si} \rightleftharpoons \text{Si-O-Si} + \text{H}_2\text{O}$ equilibrium which is believed to liberate H_2O from the hydro-

lyzed bridges above the critical weakening temperature. The H_2O apparently diffuses readily through the crystal.

The hypothesis advanced to explain this hydrolytic weakening is: (i) All dislocations are hydrolyzed but this alone is not sufficient to cause the easy dislocation motion, since the water required for 10^9 dislocations per square centimeter is nearly four orders of magnitude less than the maximum water content. (ii) Dislocations move by kink propagation when the adjacent Si-O-Si bridges in the lattice are hydrolyzed by the diffusing H_2O above the critical temperature. (iii) When the temperature is lowered and the water is no longer free to diffuse, the dislocations cannot move by this process and hence the strength is reversibly recovered.

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New Psychological Conceptions of Memory

Some recent multivariate studies of memory abilities that were forecast by structure-of-intellect theory have not only verified hypotheses generated by the theory but have also thrown considerable light upon the nature and varieties of memory.

Memory for associations, at which most previous investigations of memory have been aimed, is shown to be only one of six major varieties. Information is retained in the form of six kinds of products—units, classes, relations, systems, transformations, and implications. What have been known as "associations" are mostly identifiable with the product of implications, which are connections formed for relatively incidental reasons.

Memory abilities are also distinguishable along the lines of four major categories of information—figural (perceived), symbolic (signs), semantic (conceptual), and behavioral (psychological). Intersections of these categories with six product categories yields 24 hypothesized varieties of memory (where only visual input is concerned), 14 of which have been demonstrated experimentally, also one additional ability where auditory input is concerned.

In the use of traditional methods of investigation of human memory, such as serial learning, paired-associates, matching, and reconstruction, different products of information are emphasized. Future experiments can be more knowingly planned and results more meaningfully interpreted when the products of information are taken into account.

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Cross-Reactions of Streptococcal Group-Specific Substances in Antipneumococcal Serums

Cross-precipitations, involving up to 37 percent of pneumococcal type-specific antibodies, occur with group polysaccharides of streptococcal groups B and G and the group-specific teichoic acid of group N [hereinafter designated B, G, N, S, pneumococcal (Pn) type-specific polysaccharide, with numeral denoting type].

At 0°C, B and G precipitate an identical one-third of the type-specific antibodies in anti-Pn XXIII horse serum 912. The polysaccharides contain galactose, and L-rhamnose, and also aminosugar, N-acetylglucosamine in B and N-acetylgalactosamine in G. S XXIII, the type-specific antigenic determinant of Pn XXIII, contains D-galactose, D-glucose, phosphorus, and easily hydrolyzable L-rhamnose (J.K.N. Jones and M.B. Perry, unpublished). In B and G, also, at least part of the L-rhamnose is cleaved on mild hydrolysis with acid. S XXIII precipitates rabbit antisera to streptococcal group B but not to G. The cross-reactivities seem due to multiples, in the polysaccharides, of terminal residues or side-chains of L-rhamnose, probably reinforced by D-galactose in as yet unknown linkage.

The intracellular teichoic acid of streptococcal group N, containing galactose, glycerophosphate, and amino acids, precipitates up to one-third of the type-specific antibodies in anti-Pn VI, XIV, XVI, and XXVII horse sera. Precipitation in these may be due to the presence in N of multiple terminal residues of D-galactose or D-galactose phosphate. D-Galactose-2-phosphate holds together the repeating units of S VI, S XIV has nonreducing end-groups of D-galactose, S XVI contains glycerophosphate and galactose, and S

XXVII galactose and phosphate. Quantitative data will be given.

Supported by NSF grant.

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Protein-Solute Interactions by Density Measurements

With the magnetic densitometer it has been possible to show quite precisely that the partial specific volume (\bar{v}) of several proteins in water is essentially constant over the usual range of protein concentrations studied (< 3 percent). Accordingly, substitution of much of the water with another solute, such as is used in density-gradient centrifugation, should not affect \bar{v} if conformation and the state of hydration of the protein are unaffected; a negligible change in \bar{v} , however, does not necessarily rule out such interactions. A series of density determinations both as a function of protein concentration and of sucrose concentration for a simple protein (ribonuclease) and for a complex one (Turnip Yellow Mosaic virus) were carried out. The experimental conditions included both equilibrating the protein solution against the solvent by dialysis and the weighing in of all components relative to 1000 g water. No trend within experimental error was noted in the value of \bar{v} for either protein up to about 2 molal sucrose. The results suggest that there is no appreciable change in the hydrodynamic volume of these proteins when sedimenting into a sucrose gradient. The sensitivity of the method for measuring reproducibly small changes in density (for example, between 2×10^{-4} and 2×10^{-5} g/ml) on 0.3 to 0.4 ml of solution presents a convenient means of studying both total volume change and \bar{v} in protein systems as a function of added reagent or other variables. A study of the possible effects of other solutes is underway.

Supported by PHS grants.

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Superconductivity of the 5f Elements

The measurement of superconductivity has become a decisive way to illustrate the difference between the 4f and 5f series of elements.

The discovery of superconductivity in protactinium (I) and the detailed behavior of it, as well as that of uranium, show that the analogous position to lanthanum for the 4f series is now centered between thorium and protactinium for the 5f series. The crystal structures of protactinium and uranium are further proof for the impending beginning of the 5f series. While the β and γ modifications of uranium are superconducting above 0.7°K, the α modification will be either magnetic or superconducting, perhaps even simultaneously, but only below 0.3°K.

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The Olfactory Sense and Infrared Radiation in the Large American Cockroach

The cockroach, *Periplaneta americana*, is a favorable insect on which to conduct research. Relatively large and active, it explores for food in complete darkness. Placed in an enclosure of suitable size it moves about freely and searches the frontal 180-degree area by movements of its long antennae. An experimental arrangement provided a flat shallow cage with a copper screen bottom. This cage could be gently placed directly above a sheet of aluminum which was also 12 inches (30 cm) square. This metal surface was designed with alternate 2-inch squares painted black. The insects were tested in total darkness in groups of 20 by placement of the cage in register over the checkerboard. The cage was rotated 90 degrees at intervals of 5 minutes. Two flash photographs, an early one and a late one, were taken in each 5-minute period to record the positions and postures of the cockroaches for each of the four cage orientations. All these photos were enlarged for analysis of head and antenna positions. These analyses were made by technicians outside our laboratory. Statistical analysis

of results tabulated from our photographic records supports the hypothesis that the majority of these insect records, particularly those made within 30 seconds after a 90-degree rotation, would show a preponderance of antennae over black squares.

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Extending the Domain of Learning

While somatically innervated skeletal responses can be learned as rewarded instrumental acts, the traditional belief is that autonomically mediated glandular and visceral responses can be modified only by classical conditioning. The following experiments refute this limitation on autonomic responses and thus have implications for both learning theory and psychosomatic medicine.

Thirsty dogs rewarded by water for bursts of spontaneous salivation increased their secretion, or when rewarded for periods without salivation, decreased it. Another experiment on artificially respired rats ruled out any reflex effect mediated via learned skeletal responses by paralyzing such responses with curare. These rats learned to increase their heart rate if rewarded by direct electrical stimulation of the brain for high rates or to decrease it if rewarded for low ones; the opposite changes rule out explanation by unconditioned effects of the electrical stimulation. These rats showed no appreciable peripheral vasomotor changes, but when vasodilation was specifically rewarded it increased. When intestinal contractions were rewarded, they increased. In a different but related study, the brain waves of non-curarized cats were modified by reward. These results show that the domain of trial-and-error learning reinforced by reward can be extended to include a variety of internal activities.

J. Trowill, Leo Di Cara, and Messrs. Alfredo Carmona, and Ali Banuazizi have participated in this work supported by NIMH grant MH00647.

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Long-Term Use of Oral Contraceptives

The wide employment of progestin-estrogen combinations in monthly cycles for contraceptive purposes has led to questions concerning the effects of con-

sistent year-in, year-out use. Since the preparations used contain hormonally active components, effects on endocrine phenomena have been especially examined. Thus in the primary target organs of the female hormones study has been made of: (i) uterine function in terms of the size of the uterus, endometrial histology, and menstrual phenomena; (ii) cervical and vaginal phenomena in the analysis of Papanicolaou smears, tissue biopsies, and cervical mucus changes; and (iii) breast responses as reflected in effects on lactation, breast sensitivity, and mastitis. Secondary endocrine targets studied have been: (i) the adrenal cortex as a steroid secreting tissue, (ii) the thyroid as reflected in iodine uptake and circulation, and (iii) the anterior pituitary as a gonadotropin secretor. Possible tertiary effects upon hemopoiesis, blood pressure, and certain peripheral vascular systems and dermatologic targets have also been examined. The general findings are: (i) that endocrine effects are established immediately and are maintained for many years; (ii) extreme regularity in cyclical phenomena; (iii) apparent correction of certain abnormal states in uterus, cervix, and breasts; and (iv) no development of endocrinopathies or endocrine-related pathological states.

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Radiomimetic Beverages and Drugs

It has long been known that radiomimetic agents are mutagenic and may be carcinogenic. Tests of beverages and drugs show that alcohol, coffee, tea, and cocoa induce chromosome aberrations in the cells from onion root tip. The aberration frequency induced by ethyl alcohol was 2.9 for 0.25 percent, 6.3 for 0.5 percent, and 12.8 for 1.0 percent concentration. Weak coffee (1 tablespoon per cup) induced 9.2; strong coffee (2 tablespoons per cup) induced 19.4. Sanka coffee, free of caffeine, produced no aberrations. Thalidomide and some other antinauseant drugs induced only 4 to 5 aberrations per 100 anaphases, but poor solubility may be a limiting factor. Most of the many drugs, insecticides, and fungicides tested were not radiomimetic. For comparison with radiomimetic agents root tips were exposed continuously to gamma radiation. A dose of 25 r per day

induced 8.2 and 50 r per day induced 16.5 aberrations per 100 anaphases. If these radiomimetic agents produce comparable chromosome aberrations in man, they could be deleterious.

Research supported by PHS grant RH00294.

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Three Levels of DNA Repair in *E. coli*

The resistance of some bacteria to ultraviolet radiation is ascribed to repair mechanisms that involve the excision of pyrimidine dimers from DNA. Dimers act as inhibitors of DNA synthesis in *Escherichia coli*, and the amount of inhibition depends on dose and on the bacterial strain. We shall present data to distinguish three levels of repair of DNA in vivo. (i) Strain B_{s-1} shows no repair. DNA synthesis is permanently inhibited by doses that make 5 dimers per chromosome strand, and dimers remain acid-insoluble and photoreactivable in vivo. (Presumably the dimers remain in native DNA and block synthesis.) (ii) Strain B/r shows efficient repair. DNA synthesis is inhibited but resumes at a near normal rate even after 500 dimers per strand. Dimers rapidly become acid-soluble and non-photoreactivable, and 10 to 20 breaks per strand are observed before synthesis resumes. (iii) Strain B_{s-3} shows intermediate repair. DNA synthesis is inhibited and resumes after 50, but not 500, dimers per strand. Dimers remain acid-insoluble (as in B_{s-1}) but are no longer photoreactivable (as in B/r), and 10 to 20 breaks per strand are observed (as in B/r). A simple interpretation of the latter observations is that *E. coli* B_{s-3} has an enzymic repair system that results in the slow removal of dimers as parts of large, acid-insoluble, single-stranded DNA.

Research sponsored by the AEC under contract with the Union Carbide Corporation.

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On Regulators of Cell Division

According to genetics, "One gene, one enzyme." The production of a relatively simple substance such as histi-

dine may involve half a score of enzymes or more. These are organized to "operons," standing under command of an "operator" and work in concert in an "all-or-none" fashion (Jacob and Monod). The operator is started up or arrested by chemical signals, inducers or repressors, sent by the regulator gene. In cell division many hundreds of substances must be prepared to build a new cell. This must involve thousands of enzymes and thousands of genes, responsible for their production. This process we can also expect to be an "all-or-none" one, which means that there have to be repressors to which all operators are sensible and that there must be means to inactivate this repressor. All operators thus can be expected to have receptors for the common repressor. The chemistry of the signals, that is, that of the repressors and inducers, setting cell division in motion, as well as their mechanism of action, is unknown. Human cancer might be, essentially, the disturbance of this regulating mechanism.

The "retine" and "promine" described earlier in our laboratory have as probable function this chemical signalling. Evidence has been obtained indicating that the common receptors involve SH groups, essential for cell division, and the repressor may contain as active groups, reacting with these SH-s, a keto-aldehyde. Methods for the estimation of this group have been worked out and the probable precursor of the common receptor is being isolated.

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Nucleosynthesis in the Early Stages of an Expanding Universe

A detailed calculation of the production of elements in an expanding universe has been made. The major assumptions are that: (i) general relativity is valid; (ii) the observable universe was homogeneous and isotropic during the element-building phase; and (iii) the temperature initially exceeded 10^{10} deg K. All reactions believed to be important have been explicitly included in the computer program. The range of $h \approx \rho/T^3$ is fitted to a present $T \approx 3$ deg K and to the currently allowable astronomical limits on density. The He^4 mass fraction varies between 0.24 and 0.30 for the most reasonable choice of densities, in approxi-

mate agreement with the results of F. Hoyle and R. J. Tayler [*Nature* **203**, 1108 (1964)] and P. J. E. Peebles (preprint, 1966). In addition to D^2 , He^3 , and He^4 , it is found that possibly significant quantities of some elements heavier than He^4 can be produced by the reactions $\text{He}^3(\alpha, \gamma)\text{Be}^7(\alpha, \gamma)\text{C}^{11}$, and so forth.

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Selective Control of Insects by Juvenile Hormone Analogues

The promise of juvenile hormone as an insecticide was already evident 10 years ago in tests performed on the first active preparation extracted from male cecropia moths. When topically applied to silkworm pupae, the hormone penetrated the unbroken skin and caused lethal derangement of metamorphosis. These earlier findings have now been confirmed and extended in tests of other materials with juvenile hormone activity.

By treatment of farnesoic acid with hydrogen chloride in the presence of ethanol, John Law has prepared a synthetic analogue which shows extraordinary insecticidal action when brought into contact with immature insects ranging from Thysanura to Hymenoptera. This material is also an effective ovicide when topically applied to newly laid eggs. Meanwhile, from American newspapers and other paper products, Karel Sláma has extracted a juvenile hormone analogue which shows high insecticidal and ovidical activity for only one group of insects—the Pyrrhocoridae.

These findings point the way to the use of juvenile hormone analogues to control insects in general or specific kinds of insects. The materials in question appear to be nontoxic and without any apparent effects on plants or other animals.

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Visual Orientation in Homing Bats

The neotropical bat *Phyllostomus hastatus* in Trinidad, West Indies, displayed a homing performance consider-

ably superior to any previously recorded for other bats. In one night 94 percent of 74 returned from 3 to 6 miles (~ 5 to 10 km), 57 percent of 257 from 7 to 21 miles, and 26 percent of 112 from 25 to 33 miles. Although none of 50 returned during the first night from 39 to 40 miles, 12 percent did so over the next few days. On one occasion two out of five of these bats returned from 6 miles within 1 hour, and from some releases at 15 to 20 miles 40 percent returned within 3 to 4 hours. Like other Microchiroptera, *P. hastatus* orient well by echolocation, and when blindfolded they appeared to live reasonably normal lives within familiar territory for the few days that blindfolds remained effective. Approximately as many blindfolded bats homed in one night from 6 to 8 miles as untreated controls or bats with goggles similar to the blindfolds except for transparent windows over the eyes. But at 15 to 20 miles none of 36 blindfolded bats returned in one night with their blindfolds still effective, although half of those with goggles did so. The 2000 to 3000-foot mountains near the home caves might have been used for visual piloting. Some species of Microchiroptera are known to migrate several hundred miles. Though considerably specialized for echolocation, they may use their eyes to orient by means of landmarks and perhaps even the sun, moon, or stars.

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Deactivation by Collision in the Photolysis of Azoethane

It is known that the quantum yield in the gas phase photolysis of azoethane at 3660 Å decreases with increasing pressure. This is attributed to deactivation by collision. The excitation of azoethane by ultraviolet light is primarily an electronic process; however, a considerable fraction of the energy must go into the excitation of vibrations. As in unimolecular reactions, it is then possible for the vibrational energy to accumulate by chance in a weak bond, causing disruption of the molecule. On the other hand, deactivation may occur through collisions with other molecules. In the case of azoethane it seems likely that these two competing processes are

by far the most important, since fluorescence and phosphorescence have not been observed. The greater the amount of energy put into the molecule the more rapidly decomposition should occur, and the less effective should be deactivation by collision. We have, therefore, investigated the photolysis at 3519 and 3776 Å, obtained from a thallium-amalgam arc, and have indeed, observed this effect. Assuming deactivation at every collision, the average lifetime of the activated molecules was determined to be 1.62, 2.68, and 3.79×10^{-10} seconds for radiation of wavelengths 3519, 3660, and 3776 Å, respectively. The results can be discussed in terms of the theory of unimolecular reactions. Though not all the parameters can be completely determined, reasonable values fit in quite well with the results obtained.

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Crystalline Cytochrome *c* Peroxidase and Its Enzyme-Substrate Complex

Cytochrome *c* peroxidase, an intramitochondrial enzyme purified from baker's yeast, catalyzes the rapid oxidation of ferrocytochrome *c* in the presence of hydroperoxide [T. Yonetani and G. S. Ray, *J. Biol. Chem.* **240**, 4503 (1965); **241**, 700 (1966)]. On the addition of hydroperoxide, cytochrome *c* peroxidase is rapidly converted to a red complex (complex ES). Complex ES retains 2-oxidizing equivalents per enzyme heme, although its absorption spectrum closely resembles that of complex II of horseradish peroxidase [T. Yonetani, *J. Biol. Chem.* **240**, 4509 (1965); *ibid.*, in press]. We have recently obtained pure cytochrome *c* peroxidase in forms of large crystals ($5 \times 0.2 \times 0.2$ mm) by an equilibrium dialysis against distilled water. Upon the addition of C_2H_5OOH , these enzyme crystals have been converted to crystals of complex ES without modification in

their apparent crystalline forms. Crystals of both the enzyme and complex ES appear to be stable at 23°C for a considerable period of time. These results now make it feasible to study electronic as well as molecular interactions between the enzyme and its substrate by means of optical and electron-spin-resonance spectroscopies and ultimately by x-ray diffraction study of single crystals of the enzyme and complex ES. Crystalline cytochrome *c* peroxidase and complex ES have been compared with their dissolved forms for enzymic and physical properties such as the reactivity with ligands, light-absorption and electron-spin-resonance spectra. Of particular interest is the finding of a high concentration of unpaired-electron signal in complex ES (approximately one equivalent of enzyme heme).

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