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Molecular Rearrangements of Aryl Pinacols and the Theory of Neighboring Group Displacement Reactions

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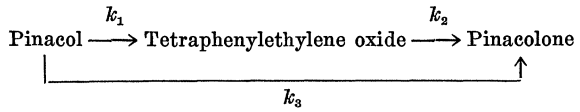
St. Louis University

A kinetic study of the acid-catalyzed rearrangement of benzopinacol (tetraphenylethylene glycol) in acetic acid solution has shown that the pinacolone is formed by way of two simultaneous reactions. Approximately 80% of the pinacolone is formed by a reaction path that involves tetraphenylethylene oxide as an intermediate, whereas the remainder of the product is formed by a direct rearrangement of the pinacol:



The rate constants k_1, k_2, and k_3 have been evaluated.

From the point of view of neighboring group displacement theory, these results indicate that participation by C_β-hydroxyl is considerably greater than that by C_β-phenyl in this reaction. Whether this is due to a thermodynamically favored participation by C_β-hydroxyl or to the decreased participation of C_β-phenyl attributable to steric factors requires consideration. There is considerable evidence that the steric factor is important in these reactions.

Orthoquartzites in Missouri

Victor T. Allen and James T. Lift
St. Louis University

The LaMotte sandstone of Cambrian age, the Roubidoux, Everton, and St. Peter sandstones of Ordovician age, the Bushberg and Aux Vases sandstones of Mississippian age, and the Graydon sandstone of Pennsylvanian age in Missouri were studied petrographically.

According to Krynine's terminology, parts of these formations are orthoquartzites. The samples studied are of sedimentary origin, are composed of 95% or more quartz, and some have a silica cement. In much of these formations the silica cement is scanty or lacking and the sandstones are friable. Locally, the silica cement is absent, and carbonates, iron oxides, and clay are the cementing materials. The term "orthoquartzite" is unsatisfactory, because to some it indicates a well-indurated sandstone and to others a metamorphic rock. Long usage, as well as petrographic study, indicates that "quartzose sandstone" is a better term for these sedimentary rocks. Where desirable the nature of the cement can be indicated by the use of adjectives, such as silicinate and calcarinate; this was proposed in 1936 by the Subcommittee on Nomenclature of the Committee on Sedimentation of the National Research Council.

The Mathematical Development of the Formulas Essential to the Intelligent Use of Countercurrent Separations where the Number of Passes is Less than Twenty Five

Willard M. Allen
Washington University School of Medicine

Countercurrent distribution of several compounds between immiscible solvents has proved to be a very useful method of separating mixtures of both known and unknown compounds. These separations can be carried out either in a series of separatory funnels or in semiautomatic machines.

When the compounds in question have sufficiently different solubility constants, the number of distributions necessary to achieve virtually complete separation can be materially reduced by selecting the proper ratio of volumes of the upper and lower layers. Further, it is relatively easy to calculate the total amount of a given compound that is present in all the tubes from analysis of the amount present in either phase in tubes at or near the maximum.

The mathematical considerations necessary for the selection of the optimum ratio of the upper and lower layers, the calculation of the distribution constants, and the total amount of the compounds present are given.

The Ecology of Introgression in *Adenostoma*

Edgar Anderson, *Washington University*

Among variation patterns studied in various plant populations, one of the most curious was in *Adenostemma fasiculatum*, a component of the California chaparral, particularly in burned-over areas. It varied widely in inflorescence pattern from plant to plant, although it was frequently uniform in other characters. Analysis demonstrated that this variation was centered around (1) a low dense-flowered complex with short, wide leaves, and (2) a tall open-panicled complex with long, narrow leaves. The latter was found growing in the "Mother Lode" country. By extrapolation, a description of the other hypothetical parent was drawn up in such detail that it was identifiable as *Adenostemma fasiculatum* var. *obtusifolium*, native to islands and headlands in southern California. A re-examination of Adenostemma populations indicated them as varying widely between these two extremes, each of which contributes a character complex valuable in certain microhabitats of the chaparral but not in others. The low complex grows in thin soil under intense radiation but is not inured to long waterless periods. The tall complex can endure drought but has deep soil and less radiation. Each of these habitats (sea-coast and oak-savannah) is known to be geologically ancient, whereas the chaparral is comparatively recent. The combined evidence presents Adenostemma as a variable bicentered complex of hybrid origin, still highly plastic and

in a state of rapid evolutionary flux under the violent impact of man.

Recent Studies of Petrified Plants from the Central American Coal Fields

Henry N. Andrews, Jr., *Washington University*

During the past ten years petrified plants have been collected in some abundance from the Pennsylvanian age coal seams of the Central States, particularly Indiana, Illinois, Missouri, Iowa, and Kansas. These occur as calcified masses of plant remains, known as coal balls, which are found in the coal itself. At present they are known from numerous localities representing a wide stratigraphical range through the Pennsylvanian.

The fossils found in these petrifactions include several groups of early seed plants, as well as abundant ferns and fern relatives. Our study of them has been undertaken chiefly to shed further light on the evolution of these groups and to trace connections with the more recent derivatives.

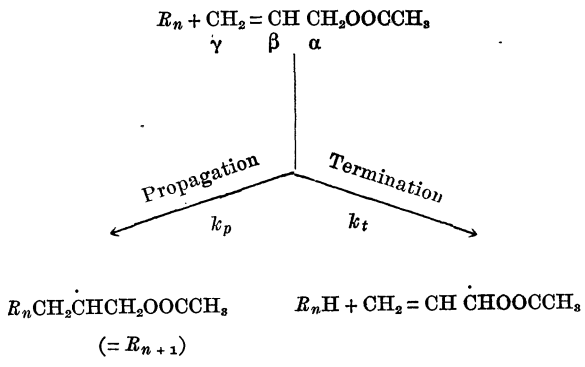
The study technique involves, first, rather extensive field exploration to obtain representative collections from as many different horizons as possible; these are prepared in the laboratory with the nitrocellulose peel method, the resultant sections being studied in essentially the same way that serial sections of a modern plant are dealt with.

These studies, now being carried on at several universities in the Midwest, have contributed notably to our knowledge of the seed ferns, the ferns, the lycopods, and articulates; we have also gained a much clearer understanding of the coenopterid ferns, a primitive group which appears to link the very primitive land plants of the Devonian with certain more advanced forms of the Carboniferous. These researches are, in general, in an early stage of development, and it seems likely that this source of information will, in the next few decades, contribute significant advances to our knowledge of plant morphology and evolution.

The Polymerization of α-Dideuteroallyl Acetate: Isotope Effects in Hydrogen Transfer

Paul D. Bartlett and Frederick A. Tate
Harvard University

It has been shown previously that in the polymerization of allyl acetate the chain-propagating and chain-terminating steps represent different modes of interaction between the same two molecular species:



Any change in the ratio $\frac{k_p}{k_t}$ between the rate constants for chain-propagation and chain-termination would be expected to affect both the average molecular weight of the polymer and the amount of polymer produced by a given amount of free-radical initiator.

Replacement of the α-hydrogen atoms of allyl acetate by deuterium indeed produces an increase of two- to threefold in these quantities. The results confirm the proposed mechanism of polymerization, since the termination reaction involves the transfer of hydrogen from one carbon atom to another and the propagation reaction does not.

There are indications in recent work that the magnitude of the isotope effect in hydrogen transfer reactions is a function of the electrical polarity assumed by the hydrogen during its transfer. These indications are discussed in terms of reaction rate theory.

Molecular Weight Determination by the Equilibrium Ultracentrifuge

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University of Virginia

Of the two general methods for determining molecular weights by the ultracentrifuge, the equilibrium method is the most reliable because it is based directly upon thermodynamic theory. The quantities measured in the equilibrium method during the centrifuging process are the rotor speed, the rotor temperature, and the concentration of the material under investigation across the centrifuge cell. In addition, the rotor speed and temperature must be held constant (or allowed to change slowly by a known amount) over a long period of time. The partial specific volume of the substance, which also must be known, is determined in separate experiments.

In the experiments here described the ultracentrifuge rotor is magnetically suspended in a vacuum and driven to the desired speed by an air turbine situated below the vacuum chamber. A thin, flexible shaft which passes through a vacuum gland connects the turbine and rotor. At operating speed the shaft is disconnected and the rotor coasts freely during the experiment, which usually extends over several days. The deceleration of the 7.5″ diameter rotor is approximately 1 rps/day, and the rotor speed can be measured to one part in 10 million if so desired. The rotor temperature is held constant to within 0.01° C. The refractive index across the centrifuge cell, from which the concentration is found, is determined by a special interferometer method in which a fringe shift of less than 0.1 fringe can be measured. As a result, the precision is greater than in previous experiments and the observation can be extended to more dilute solutions.

The Limiting Thickness of an Electrolyzed Gas Film Capable of Sustaining a Given Negative Pressure

Lyman J. Briggs, *National Bureau of Standards*

The critical thickness of a gas film that is just capable of withstanding a given negative pressure P_N in a liquid column has been studied. The film was generated electrolytically on the surface of a spherical platinum electrode of known area. The number of gas molecules correspond-

ing to the measured charge required to release the negative column was then computed from the relation between the Faraday constant and Avogadro's number. The number of gas molecules required to form a monolayer on the electrode was next computed from the molecular diameter, based on van der Waals' equation. The ratio of these numbers gives the thickness, t, of the film in fractions of a monolayer.

Both H_2 and O_2 gas films were used. Measurements were made at various negative pressures, ranging from $P_N = 160$ cm water, $t = 0.54$ monolayer, to $P_N = 8.5$ cm, $t = 0.99$ monolayer. The results lie on a smooth curve, represented approximately by the equation $P_N = kt^{-5}$; i.e., the effectiveness of the film is inversely proportional to the fifth power of its thickness.

Throughout the range of these experiments, the film is less than one monolayer in thickness, becoming complete when $P_N = 10$ cm water. The computed thickness varies with the value chosen to represent the diameter of the molecule.

Color Markings on Pennsylvanian Pelecypods

Kenneth G. Brill, Jr., *St. Louis University*

Traces of color markings have been found on three genera of pelecypods from upper Pennsylvanian strata in San Miguel Co., N. M.

Streblochondria sp., a smooth-shelled pectinoid, shows about nine dark bands alternating with wider light bands. All bands radiate from the beak.

Acanthopecten carboniferous, a pectinoid, has dark concentric growth lines studded with dark spinous processes on a lighter background.

A form that is probably *Edmondia gibbosa* has a light surface speckled with dark. The minute spots are arranged in rows radiating from the beak.

The pelecypods occur with bryozoans, brachiopods, and gastropods in a yellowish-gray calcareous silty shale. None of the other fossils shows evidence of color markings.

Mechanism of Lysis of Bacteria by Bacteriophage

J. Bronfenbrenner, *Bowman-Gray Medical School*

The mechanism responsible for the lysis of the phage-infected bacteria has not received much attention; a review of existing evidence pertaining to this subject may therefore be of interest.

If a freshly seeded culture of bacteria is divided into two portions and a moderate amount of phage introduced into one of them, such phage-infected culture becomes turbid sooner than the control because of the accelerated growth of bacteria. After a relatively short period, however, this turbidity rapidly disappears as the result of lysis of bacteria. At this time the amino nitrogen content of the lysed culture is found to be considerably higher than that of the uninfected control. Microscopic examination reveals that during the period preceding lysis the infected bacteria undergo considerable swelling and, eventually, sudden disintegration, as if by bursting.

If one seeds bacteria upon the surface of a solid medium containing a relatively high concentration of agar or gelatine, bacteria still respond to infection with phage by exhibiting increased rate of multiplication, but the swelling and lysis are prevented. However, incorporation of appropriate concentrations of urea into such media permits the swelling and lysis of bacteria to take place.

These observations suggest that the primary result of exposure of susceptible bacteria to bacteriophage consists of markedly increased bacterial metabolism accompanied by hydrolysis of cytoplasm and the resulting increase in the intracellular osmotic pressure. If free water is available, it enters the bacterial cells, causing them to swell and eventually to burst. If one sets up competition for water by increasing the concentration of agar in the medium, the swelling and bursting of cells are prevented. Highly diffusible ions of urea, being highly hydrated, penetrate the cells and accomplish the transfer of water against competition by agar and thus make possible the swelling and bursting of bacteria.

Characteristics of Thunderstorm Microbarograms

Edward M. Brooks, *St. Louis University*

The following outline indicates the classification used:

I. Microcyclone
   - *a*) With tornado (tornado cyclone)
   - *b*) Without tornado

II. Pressure rise
   - *a*) Pressure jump
   - *b*) Before thunderstorm high

III. Thunderstorm high
   - *a*) Accentuated by hail
   - *b*) Well-developed thunderstorm
   - *c*) Shower or weak thunderstorm

IV. Pressure drop
   - *a*) Rear of well-developed thunderstorm
   - *b*) Rear of shower or of weak thunderstorm

V. Rear low
   - *a*) With strong convergence (sometimes producing arched cloud)
   - b) Behind shower or weak thunderstorm

The Effects of Pre- and Postnatal Anoxia upon Learning and Memory Ability at Maturity

Marion E. Bunch, *Washington University*

Approximately 450 white rats were used in investigating (1) the effects of severe oxygen deprivation (3% equivalent oxygen for 30 min) within 2 hr after birth upon the ability to learn and remember at maturity, and (2) the effects of severe oxygen deprivation during the fetal period upon learning ability at maturity. In the latter condition, pregnant females were exposed to simulated altitudes of 30,000′ for 2 hr. Of the offspring, 100 learned the maze problem as adults and were compared with 100 normals at same age. Littermate controls were used in the first part of the study.

The principal learning problem for the rats on which this report is based is the multiple-T 14-unit water maze. Standard procedures were used in measuring learning and retention; retention interval was 30 days. Animals were started on learning tasks at approximately 70 days of age.

Results: Ability of white rats at maturity to learn and remember a difficult maze problem is not affected by severe exposure to anoxia (3% equivalent oxygen) for 30 min within 2 hr after birth. The effects of severe exposure to anoxia during the fetal period upon learning ability at maturity were marked and statistically signifi-

cant. The anoxic animals were decidedly inferior to their controls in the measures of learning.

A New Case of Cryptic Species in *Drosophila*

Hampton L. Carson, *Washington University*

A Brazilian species of fruit fly, *Drosophila bocainensis* Pavan and da Cunha 1947, has been shown by the examination of salivary gland chromosomes to consist of three discrete populations which do not interbreed under natural conditions. These entities may thus be properly described as species, despite the fact that there are only obscure and cryptic morphological and physiological differences between them. Two of these specific entities, *D. bocainensis* (*sensu stricto*) and *D. parabocainensis*, although they coexist in the same geographical areas without hybridization, freely interbreed under laboratory conditions, with luxuriant production of offspring. Tests of these hybrids have shown that, unlike previous cases in this genus, they are highly fertile, with the exception of one type of hybrid male that is only partially fertile. No information exists concerning the factors that effectively prevent crossing between these "sibling species" in nature, although there appear to be reciprocal changes in frequency of the two species with season, suggesting that ecological differences are involved. No hybrids have been obtained between the third entity, *D. bocainoides*, and either of the other two, and this species is clearly somewhat separated from them phylogenetically. These findings have important implications with regard to problems of the mechanics of isolation and evolution.

Immunologic Studies of Fetal Hemoglobin

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Washington University School of Medicine

Techniques have been developed, using antifetal hemoglobin serum of high potency and specificity, for the qualitative and quantitative determination of fetal hemoglobin (F hemoglobin) in human blood specimens. The production of antihemoglobin sera of high titers has been made possible by the use of adjuvant mixtures to increase the antibody response evoked by the weakly antigenic material. In the present investigation, pure fetal hemoglobin has been employed as antigen. The latter was separated from other forms of human hemoglobin by taking advantage of the resistance of fetal hemoglobin to denaturation by highly alkaline reagents. Absorption studies suggest that the antifetal serum is specific for the embryonic pigment. A quantitative precipitin reaction, based upon a straight-line relationship between the logarithm of the time in minutes required for the precipitin ring to become apparent and the logarithm of the amount of F hemoglobin, has permitted the estimation of extremely small quantities of this compound.

Results of the study reveal that (1) fetal hemoglobin occurs in normal adult individuals in small amounts, the maximum being less than 1.0% of the total hemoglobin and, in general, less than 0.5%; (2) the alkali-resistant hemoglobin fractions detected by the denaturation technique in many instances of the hereditary hemolytic syndromes, and occasionally in acquired hematologic diseases, are immunologically identical with normal fetal hemoglobin. Comparative results between the values for F hemoglobin obtained by the alkali-denaturation technique and the quantitative precipitin test were in excellent agreement.

A Study of Oxidative Phosphorylation with Oxygen 18–Labeled Phosphate

M. Cohn, *Washington University School of Medicine*

An attempt has been made to gain some insight into the nature of the interaction between oxidation from substrate through the electron transport system to oxygen and phosphorylation by labeling the inorganic phosphate which participates in these reactions with oxygen 18. The rationale of the method was based on the probability that the phosphate group does not proceed through a series of reactions intact but may lose one or more of its original oxygen atoms.

A new reaction which occurs in oxidative phosphorylation associated with the electron transport system has been observed in rat liver mitochondria with α-ketoglutarate, β-OH butyrate, and succinate as substrates. This reaction manifests itself by a replacement of oxygen 18 and parallels the phosphorylation associated with the oxidation. The number of molecules of inorganic phosphate which participate in this reaction, calculated on the basis that a monoester of phosphate is involved, is several times higher than the number of high energy phosphate bonds that can be formed. The reaction does not occur at the substrate level oxidation of α-ketoglutarate, and the evidence suggests that it occurs at every step in the electron transport system.

This phosphate turnover reaction occurs only when phosphorylation is proceeding. Dinitrophenol suppresses the reaction. The omission of Mg^{++} or adenylic acid also suppresses the reaction. The possibility that the reaction is due to a direct reaction of ATP, hydrolytic or otherwise, is eliminated. Various mechanisms which are consistent with the findings are discussed.

Studies on the Biosynthesis of Tobacco Mosaic Virus

Barry Commoner, *Washington University*

The reduplication of tobacco mosaic virus in tobacco leaf has been studied by comparing nitrogen metabolism of infected and uninfected tissue. Changes in the following components during virus biosynthesis have been quantitatively determined: tobacco mosaic virus; total nitrogen; total protein; total nonprotein nitrogen; free ammonia, amide and amino nitrogen; individual free amino acids and amides. Changes in a series of protein fractions have also been studied by electrophoresis and by other means. The data show that: (1) Synthesis of virus induces withdrawal of host nonprotein nitrogen (chiefly ammonia, glutamine, asparagine, glutamic and aspartic acids, and serine). (2) Previous to virus formation, infected tissue synthesizes an excess (as compared to uninfected tissue) of an insoluble protein component. (3) During virus formation a transitory excess of soluble protein occurs. (4) Several specific soluble low molecular weight proteins are synthesized along with the virus in infected tissue.

These observations and investigations of infected tissue cultured in nutrient containing N^{15}-labeled ammonium ions lead to the following conclusions: (1) Virus protein nitrogen is derived from free ammonium nitrogen, with-

out passing through the pool of free amino acids and amides. Therefore, virus protein synthesis involves *de novo* formation of peptide bonds either from ammonia or from a component derived from ammonia which is *not* free amino acid or amide nitrogen. (2) The nonvirus soluble proteins synthesized *de novo* in infected tissue may represent virus precursors. (3) The site of synthesis of virus or of its protein precursors is probably an insoluble cell particulate.

Man's Awareness and the Limits of Physical Science

A. H. Compton, *Washington University*

Attention is called to the conflict between the views of Bohr and Schrödinger regarding the nature of the physical world. Bohr considers this to include only that which can in principle be verified by observations using material instruments. Schrödinger introduces the hypothesis of a physical continuum, typified by the concepts of wave mechanics, whose changes follow a strictly causal determinism, but of which observations with material instruments can give only partial information.

Making use of Bohr's evidence that one's awareness of his intentions makes possible the prediction of his actions more definitely than is in principle possible from physical observations, a category of ideological reality is introduced. This category includes feelings, ideas, intentions, etc., of which one is immediately aware. It is distinguished from the physically real world as defined by Bohr. In terms of this distinction, Schrödinger's determined continuum has ideological but not physical reality. The question remains whether this continuum may have objective reality outside the physical world.

The usefulness of one's awareness of his intentions in forecasting physical events suggests the following rather obvious hypothesis: that there exists an objective world regarding which physical observations reveal one aspect and man's awareness reveals another. Such a world is not evidently related to Schrödinger's continuum. The present hypothesis can, however, be used in reconciling the "outer" physical indeterminateness of man's actions with a high degree of "inner" determinateness. Here seems to be an answer to Schrödinger's criticism of the concept of an undetermined world as violating the reasonable inference of self-determined actions associated with the sense of moral responsibility.

Structure of Glycogen and Enzyme Patterns in Glycogen Storage Disease

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Understanding of the mechanisms of action of the 3 enzymes necessary for the synthesis and breakdown of glycogen has been helpful in the elucidation of the structure of glycogen. These enzymes are: (1) phosphorylase, which catalyzes the synthesis and breakdown of the prevalent 1 : 4 maltosidic linkage; (2) amylo-1,6-glucosidase, which catalyzes the hydrolytic fission at the branch points, with glucose as one of the reaction products, and which acts only after exhaustive phosphorylase action; (3) the "branching enzyme" (a transglucosidase) which exchanges an α 1 : 4 for an α 1 : 6 link, transferring a chain of about 3 glucose residues, probably within the same branch.

Studies with these enzymes have led to a formulation of glycogen as being a treelike compound, confirming the postulations, based mainly on physical measurements, of K. H. Meyer.

Enzymatic structure analyses were carried out on animal and plant glycogens. The percentage end group varied from 8.3 to 5.8, showing that there exists a continuous series, and not just the two extremes, as had been claimed previously. In most cases of glycogen storage disease, no deviation from the normal pattern was found. There were, however, two exceptions: one case in which muscle and liver glycogen had a branch point percentage of 13 and 11, respectively. This was due to the outer chains being extremely short so that the 2 polysaccharides resembled phosphorylase limit dextrins. In the second case, only liver glycogen was available for analysis. It resembled closely the branched fraction of starch (amylopectin) in having a branch point percentage of only 4.7. It also had the physical characteristics of amylopectin (iodine color, solubility, x-ray diffraction pattern). In a number of cases with normal glycogen structure, autopsy and biopsy specimens of the liver were tested for glucose-6-phosphatase activity. In two fatal cases the enzyme was found to be at very low level of activity. In two out of four surviving storage disease cases, all with mild symptoms, the activity of the glucose-6-phosphatase was below the level found in other liver diseases. The pathogenesis of the disease in terms of deficiencies of several enzymes is discussed.

A Possible Mechanism of Excitation of Nerve Impulses in the Cochlea

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Central Institute for the Deaf

In the cochlea the membranous labyrinth, filled with endolymph and containing the sensory cells for hearing (in the organ of Corti), lies on the basilar membrane and forms part of the so-called cochlear partition between the scala vestibuli and the scala tympani. It constitutes the "scala media." Mechanical movements of the cochlear partition somehow initiate nerve impulses in the nerve fibers that innervate the sensory cells. We suggest that the sensory cells do not themselves respond like nerve fibers but serve to modulate a flow of electricity from the scala media to the scala tympani.

Some important facts on which this hypothesis is based are: (1) There is a large d-c electric potential across the organ of Corti and basilar membrane between scala media and scala tympani. (2) An alternating electric potential closely related to mechanical vibration of the cochlear partition seems to originate at the specialized ends of the sensory cells—i.e., at the surface in contact with the endolymph in scala media. (3) The two potentials are closely related to one another and depend on an adequate oxygen supply. (4) The alternating potential and nerve impulses are more sensitive to changes in potassium concentration in scala tympani than in scala vestibuli. It is therefore likely that the specialized ends of the sensory cells and not the basilar membrane are the major barrier to electric current flow from scala media to scala tympani.

Two major assumptions are: (1) Mechanical move-

ment of the specialized "hairs" of the sensory cells in the proper direction alters the resistance of the major electrical barrier. (2) The energy that maintains the positive potential of scala media is derived from the metabolism of the stria vascularis, a glandlike structure in the scala media close to its blood supply.

According to this hypothesis, the sense organ does not merely transduce the energy of the stimulus. The stimulus controls the release of additional energy from an especially available source. The organ is comparable to a carbon microphone circuit in which a change of resistance in the microphone modulates the flow of d-c current from a battery through a well-defined circuit. In the cochlea the nerve endings on the sensory cells are part of this circuit and can be stimulated by the changes in the current flowing through them.

Several features of the anatomy of the organ of Corti, the stria vascularis, etc., that lend support to this hypothesis are pointed out.

The Chemical Characterization and Submicroscopic Structure of Elastic Tissue

Edward W. Dempsey

Washington University School of Medicine

Elastic tissue occurs variously in mammals as fibers ranging from 5 μ in diameter to the limit of microscopic visibility, and as fenestrated lamellae. In different species, locations, and ages, elastic tissue exhibits minor differences in staining reactions, but in general it is characterized by an extremely slight affinity for acid or basic dyes and by a selective affinity for orcein when applied in acid alcoholic solutions. These latter dyes contain phenolic groups, and their uptake can be prevented by previous saturation of the elastic tissue with naphthoic compounds. Irreversible or competitive reaction of the acid or basic radicals does not alter the affinity of elastic tissue for orcein. The uptake of orcein is influenced only slightly by pH. Such results indicate that the bond uniting orcein and elastic tissue is not ionic, but some other type of interaction.

Elastic fibers are insoluble in all ordinary solvents. An enzyme, elastase, renders the fibers soluble without forming free amino acids. During digestion large fibers split longitudinally into two smaller fibers; these in turn cleave into still smaller fibers. Observations made with the electron microscope indicate that small fibrils (*ca* 200 A in diam) are ultimately produced. Thin sections of elastic fibers and plates, shadowed with chromium, reveal that these small fibers are arranged in an anastomosing network, randomly oriented in the relaxed fiber. In stretched fibers, these fibrils become increasingly parallel, thus forming a basis for the fact that elastic tissue is isotropic when relaxed but birefringent when stretched.

A Comparison of the Metabolism of some Female Sex Hormones

E. A. Doisy, Jr., B. C. Bocklage, N. H. Shen, and A. F. Valcourt

St. Louis University School of Medicine

In these studies progesterone-21-C^{14}, 17-C^{14} H_3-estradiol-17β, synthesized in our laboratories, and commercially available estrone-16-C^{14} were administered separately to three main types of adult spayed rats of the St. Louis University colony. Doses within the physiological range were employed whenever possible. The excreta and, in some instances, expired CO_2, bile, and lymph were collected for C^{14} assay.

No significant amounts of $C^{14}O_2$ were present in the expired air of animals receiving 17-CH_3-estradiol, but animals receiving progesterone excreted up to 15% of C^{14} in the expired air. Normal animals excreted the majority of the administered C^{14} in their feces, whereas values from 56 to 96% of the administered C^{14} were found in the bile of rats with bile fistulas. It is apparent that the liver of the normal animal constitutes the major excretory pathway of C^{14} in these compounds.

Animals in which the bile ducts had been doubly ligated and severed excreted most of the C^{14} in the urine, showing that the kidney can assume this role of the liver when the flow of bile has been interrupted. In addition, acute experiments on the routes of absorption and distribution in tissues have been performed.

The Metabolism of Androgens

William H. Elliott, James Ashmore, and Paul M. Hyde

St. Louis University School of Medicine

Representative androgenic steroids labeled with C^{14} have been prepared and utilized in a study of the metabolism of the male sex hormones in the rat. In experiments carried out over a period of 4 days following intramuscular or intragastric administration of physiological quantities of testosterone-4-C^{14}, 17-methyl-C^{14}-Δ^5-androstene-3β, 17β-diol, or 17-methyl-C^{14}-testosterone, most of the radioactive metabolites were found in the feces of normal animals and in the bile of animals with bile fistulas. When the biliary role of excretion was blocked by ligation of the bile duct, the kidney assumed greater importance as an excretory organ, since the major amount of radioactivity was always found in the urine in these experiments.

Studies on the hydrolysis of the biliary radioactive metabolites of testosterone have demonstrated the presence of a major portion in the form of glucuronides.

Steroid Compounds Resulting from Incubation of Cortisone with Surviving Liver Slices

Albert B. Eisenstein

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The ability of surviving liver tissue to alter the chemical structure of steroid hormones has been demonstrated. These studies have been concerned primarily with inactivation of androgenic and estrogenic substances. Adrenal steroids have not been extensively studied in this manner, although Schneider has recently reported catabolism of cortisone by rapid reduction of the conjugated unsaturated bonds in ring A of the molecule and extensive degradation of the α-ketol side chain when incubated with rat liver slices.

The purpose of the present study was to determine if cortisone is actively metabolized by surviving liver slices and to detect and characterize any new compounds that might result from such metabolic processes.

Rat liver slices were incubated in the presence of small amounts of cortisone. After incubation the steroid frac-

tion was recovered and analyzed by paper chromatography. Chromatograms demonstrated the presence of 3 steroid compounds.

The steroids were eluted and then characterized by determination of absorption spectra in ultraviolet light, by formation of sulfuric acid chromogens, by certain color reactions, and by comparison of mobility on paper with that of known compounds.

The compound that moved most rapidly on paper was cortisone, unchanged by incubation. The second compound, of intermediate polarity, proved to be Compound F. The third, and most polar steroid, is not completely identified. Analysis indicates that this substance retains the conjugated unsaturated bonds but the α-ketol side chain at C-17 is altered.

The results demonstrate that the liver can convert cortisone to Compound F. Since Compound F is biologically active, this evidence indicates that the liver metabolizes steroids not only by inactivation but may produce other active hormonal substances.

Fructose as a Source of Calories during Intravenous Alimentation

Robert Elman and Theodore E. Weichselbaum

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Starvation was formerly inevitable and sometimes fatal in patients unable to eat. Injection of needed nutriments directly into the blood stream (intravenous alimentation) in such cases has already extended greatly the boundaries for the conquest of disease. To supply calories in this way the carbohydrate glucose (dextrose) has been employed. Glucose has the disadvantage of remaining outside the cell for some time after infusion, which leads to a large loss of sugar in the urine. Fructose, a carbohydrate widely distributed in nature, and just as effective as glucose as a source of calories, was found to enter the cell rapidly and to appear in only small amounts in the urine. More important, fructose is better than glucose for protein synthesis from infused amino acids, which are often given as part of the intravenous diet as a source of protein food. The reason is that after intravenous infusion amino acids enter the cell just as rapidly as fructose, both being metabolized together, the one for energy, the other for protein synthesis. By contrast, amino acids given with glucose tend to be used for calories rather than protein synthesis, because energy needs are given first priority and the infused glucose at this time is still outside the cell. The thesis that fructose is a better source for calories than glucose during intravenous feeding is supported by evidence obtained from observations made in human subjects.

The Lipotropic Action of Proteins

C. A. Elvehjem, *University of Wisconsin*

Twenty years ago Best and co-workers demonstrated that rats fed diets low in protein developed fatty livers and that choline added to the ration prevented the accumulation of this fat. Later it was shown that the accumulation of fat decreased as the level of protein in the diet was increased. Tucker and Eckstein showed that this lipotropic action was related to the methionine present in the protein. During our studies on the relation of tryptophan to niacin metabolism diets containing 9% casein were used; we were surprised to find that the level of liver fat was above normal even when adequate amounts of choline or methionine were supplied. When choline was omitted from the basal ration containing 9% casein, the liver fat was 20–25% on the fresh weight basis. The addition of choline reduced the level to 8–10%, but a normal level of 3–4% was obtained only upon addition of 3–6% casein or gelatin. Individual amino acids such as proline, threonine, arginine, and glycine have some effect in reducing the amount of fat, but it appears that a combination of two or more amino acids is needed for the complete effect. These amino acids have no effect in the absence of methionine but function in addition to methionine in preventing the deposition of fat. When the carbohydrate in the ration is changed from sucrose to starch there is an increased rate of growth and a decrease in the liver fat, although a normal level is not reached. The possible relationship to the disease known as kwashiorkor is discussed.

Oil Structures Deduced from Soil Studies

Albert J. Frank, *St. Louis University*

A study of the heavy and light minerals and clay minerals of soils derived from Pennsylvanian rocks with known mineral content has made possible the drawing of structural maps in Illinois. The maps become inaccurate with increasing thickness of the Pennsylvanian section resulting from unconformities within the Pennsylvanian. Likewise, unconformities in the underlying rocks limit the method to near-surface rocks. With experience the soils can be identified at sight and possible structures seen from the air.

The Brodeur Biplane Serialograph

Lloyd L. Garner, *St. Louis University*

A report on the biplane serialograph, its various uses in research concerning heart and circulatory disorders, the branches of science used in its design and fabrication, and the special problems therein involved, is presented.

In the field of radiology, the biplane serialograph represents one of the greatest strides forward in the past decade and is the best method, to date, of obtaining serialized x-ray photographs for diagnostic purposes.

Cigarette Smoking and Cancer of the Lung

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Washington University School of Medicine, Memorial Center, New York,* and *Washington University

Primary cancer of the lung has increased in frequency so much in the past 40 years that it is now the most common internal cancer in the male sex. Statistical studies, published by the authors in 1950, and a little later in England by Doll and Hill, are in remarkable agreement, showing that in cases of cancer of the lung there is almost always a history of excessive cigarette smoking for a period of at least 20 years and that it is rare to find a case in a nonsmoker. Also, we have obtained direct evidence that tar obtained from cigarette smoke will produce cancer experimentally when painted on the skin of mice

over a period of about a year. Demonstrations of the experimentally produced cancers are presented.

Factors Affecting the Viability of Influenza Virus Suspensions Subjected to the Freeze-drying Process

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St. Louis University

Using an all-glass, high-vacuum molecular still, PR8 influenza virus in allantoic fluid was lyophilized under different conditions. The apparatus permits the manipulation of any of 8 sets of duplicate ampules without disturbing the others. The end point of dehydration was determined by using ionization gauges. At 10° C, for example, no further loss of water occurred after 3 hr. The factors studied were (1) the treatment of the material prior to dehydration, (2) temperature at which dehydration was carried out, and (3) the effect of incubation at 37.5° C on the dehydrated material. Dehydration at 26° C subsequent to precooling for 10 min at − 80° C resulted in a higher rate of virus survival than did precooling at − 30° C or 0° C. The titer of virus suspension precooled at − 80° C was higher after dehydration at 0° C than after dehydration at − 30° C, or under conditions such that the temperature rose from − 80° C to − 10° C over a 48-hr period. Virus lyophilized under various conditions showed no appreciable loss of titer on storage at − 40° C; at 37.5° C, however, there was invariably some loss of titer, most marked during the first 3 days. This loss of titer on incubation was greater in virus suspensions dyhydrated at 0° C (which showed no loss of titer immediately after drying) than in suspensions lyophilized between − 80° C and − 10° C (which showed considerable initial loss).

An Investigation of the Concept of Integration

Stanley C. Grzeda, *St. Louis University*

The term "integration," current in psychological literature, is vague. It may denote an organizing process, an organized state, a reducing process, or be used as a synonym for adjustment. The present study was carried out to determine if a core of agreement exists among psychologists in their use of the concept of integration when rating combinations of responses to inventory questions.

The rating group numbered 49 and included both graduate students and faculty at the University of Illinois. Eighty-one pairs of questions taken from a personality inventory compiled by McQuitty were included in 4 rating scales. The materials were presented for rating following the procedure outlined below.

Each inventory question solicited one of three responses, *Yes, Between,* and *No.* For each pair of questions there were 9 possible combinations of responses: *Yes* to the first question and a *Yes* to the second, *Yes* to the first and a *Between* to the second, Y1–N2, B1–Y2, B1–B2, B1–N2, N1–Y2, N1–B2, N1–N2. Each of these combinations was rated according to the degree of integration reflected in it, in the judgment of the 49 psychologists.

Indexes of agreement were computed. The ratings for the question-response combinations were intercorrelated and factor-analyzed, using Thurstone's centroid method.

Results were as follows: (1) The indexes of agreement —i.e., average correlations—ranged from .07 to .90; the median was .51. (2) Two factors were abstracted, but one was thought to rise from conditions other than the question content. It is suggested that corrections in the wording of questions would have resulted in a single factor. (3) The items with the highest average correlations are related to McQuitty's integration measures.

The Role of Descartes in the Rise of Physiology

Thomas S. Hall, *Washington University*

The occasion of this report is the completion of the first English translation, as far as the author can discover, of Descartes' physiological essay, *Concerning Man.* In this paper, Descartes presents a thoroughly materialistic account of a variety of physiological functions and displays shrewd insights into physiological problems and issues of the mid-seventeenth century. His approach is that of asking the reader to imagine a marvelous machine capable of all the functions of which the human body itself is capable. Wherever possible, in describing the functions of the machine, Descartes draws on well-attested empirical fact. Where such fact is unavailable, he draws upon the speculations of earlier scientific thinkers and sometimes upon his own active imagination. This contradictory compounding of science and speculation is rendered more acceptable than it might otherwise be through the technique of using a hypothetical machine as the subject rather than man's body itself. Actually, the ruse is a thin one, and the admixture of fact and fancy becomes irritating to the serious reader at certain points. Scientifically, the essay is significant in being the first frank attempt to bring the totality of organic functions within the purview of Galilean mechanistic materialism. It gives the first well-elaborated and substantially correct account of physiological optics. Philosophically, it is significant in having established the famous Cartesian dualism, under attack in present-day systems, of matter vs. mind. Perhaps its chief effect lies in what it did to man's view of man, since it dared him to consider himself as something to be understood in terms of natural rather than transcendental philosophy.

Effects of a Diffusible Mouse Tumor Agent on the Growth of the Nervous System in the Chick Embryo

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Washington University

The implantation of mouse sarcoma 180 and 37 into early chick embryos results in a selective growth promotion of spinal and sympathetic ganglia, whereas the somatic motor system is refractory. The tumor implants are invaded by large masses of fibers emerging from the hyperplastic ganglia. The growth-promoting agent is diffusible, as was demonstrated by the implantation of tumors onto the extra-embryonic membranes. In this case, not only was a striking overgrowth of the normal sympathetic ganglia observed but also a neoformation of atypical ganglionic masses. Large fiber bundles from these ganglia invade the adjacent viscera (mesonephros, gonads, spleen, thyroid gland, and others) which receive normally only a sparse innervation or none at all, at corresponding

developmental stages. The fibers do not establish synaptic connections.

The following points deserve further analysis: the chemical nature of the growth-promoting tumor agent and its selective effects; the apparent breakdown of the regulative mechanisms which normally prevent a hyperneurotization of viscera; the apparently unchecked spinning out of fibers; the question of whether the potential sympathoblasts or the viscera are the immediate target of the tumor agent; in the latter instance, the viscera would be induced to admit excessive numbers of nerve fibers and the latter would mediate the effect to the ganglia.

The Reliability of Measurements of Energy Metabolism

Francis L. Harmon, ***St. Louis University***

Because of the widespread use of metabolism tests, both in clinical practice and research, the question of the reliability of such measurements is of crucial importance. Studies dealing with various aspects of this question have been reported; yet it remains a fact that the reliability of the metabolism test has not been satisfactorily determined to date. This seems to have been due partly to the application of relatively inefficient and, in some cases, inappropriate statistical methods to the problem, and partly to a faulty analysis of the problem itself. More specifically, previous investigators have not usually distinguished clearly enough between the stability of the metabolic rate and the precision with which the typical test measures this rate.

The general aim of the present study is to investigate the reliability of measurements made by the closed-circuit method upon 29 ostensibly normal, young adult males. Three steps are involved: (1) carrying out a complex analysis of variance upon a set of 348 test records, in order to isolate certain major sources of variation and evaluate the significance of each; (2) derivation, from the preceding analysis of a valid estimate of the error of measurement of the metabolism test; and (3) the establishment of other critical values for estimating the significance of changes in metabolic rate under certain specified conditions. Results obtained by this approach are described, together with examples of their applications.

Cutaneous Autonomic Reaction Patterns Servicing Temperature Regulation

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Cutaneous blood flow and sweating at various environmental temperatures exhibit definite regional patterns. Cutaneous vasodilatation is first observed on the fingers, then the toes and subsequently on other skin areas. Sweating begins on the dorsum of the foot, ascends the leg, appears on the hand, then the trunk and head. This order of recruitment suggests thermoregulatory spinal reflexes. After recruitment is completed, subsequent increases in cutaneous blood flow and sweating occur simultaneously over the entire skin surface, suggesting control by the hypothalamic centers. Considerable variation is exhibited in these patterns in various individuals. The extent of cutaneous arterial dilatation is less in some subjects than in others and implies corresponding differences in the circulatory loads imposed by heat.

Phenomena in the Liquid-Liquid Critical Region

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University of California

The critical point of a liquid-liquid system is customarily defined either by zero values of the first and second derivatives of activity with respect to total composition or by disappearance of the liquid-liquid interface. Additional criteria are available. The rapid increase in randomness of distribution, as a 2-phase mixture is raised to the critical region, suggested a corresponding increase in entropy. We have measured the heat capacity of a critical mixture of 2,2,4-trimethyl pentane and *n*-perfluoroheptane, from which association effects are absent, and found a steep cusp in the curve of heat capacity vs. temperature. Two liquids that are incompletely miscible dissolve in each other with large volume expansion, hence the volume-temperature curve also has a characteristic form with a break at the point of coalescence.

Certain Temporal Factors in Audition

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This theoretical presentation attempts to show that the four basic physical dimensions, three of space and one of time, are not all equally important nor in the same order of importance for perception in all sense modalities. Theoretical and experimental literature on visual perception reveals a consistent preoccupation with spatial dimensions (primarily the two of the frontal plane), with relatively little concern for visual changes in time except for the studies on perceived movement.

Everyday visual perception is characterized by the discrimination of various shapes, extents, textures, and other qualities that are spread out in space. The referent for visual perception is the *object.* The important dimensions, therefore, are the properties of objects. Auditory perception, on the other hand, can rarely be referred to objects. We do not hear objects, but rather *events.* And the important dimension, therefore, for audition is the basic dimension for events—namely, time.

Study of the perception of time has been concerned mostly with comparison or absolute judgments of duration. It is proposed that time be used as a dimension in which stimuli are arranged or patterned in order to provide data that can describe the principles of operation of time-based sense modalities, such as audition.

If the above notions are correct, *visual acuity,* a measure of an *interval of space* between two visual stimuli that are perceived as two, is the important measure for predicting visual capacity for reading and other forms of discrimination of spatial patterns. The implication of these notions for audition is that the basic measure of auditory capacity is another *interval,* now *of time,* that is necessary in order that two successive acoustic stimuli are perceived as two. Lack of such a measure of auditory capacity, which is analogous to visual acuity, is largely responsible for the lack of good correlation between ex-

tant psychophysical measures of audition and the ability to perceive and discriminate adequately everyday auditory phenomena.

Exploratory experiments on temporal acuity or resolution in vision, audition, and tactual vibration reveal that these three senses differ widely with respect to the perception of temporal patterns. These, together with comparative results on auditory and visual fusion, reveal the clear superiority of audition when rapid stimulus changes are to be discriminated.

Photosynthesis: Old Problems in New Guises

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In recent years certain previously inaccessible areas of photosynthetic inquiry have been opened to biochemical research. This is owing, on the one hand, to the availability of isotopic-labeling methods combined with new analytic techniques that enable researches to be performed elucidating the character of intermediary metabolites formed during reaction periods of as little as a few seconds. On the other hand, noteworthy success in producing stable, active cell-free systems exhibiting a number of the partial reactions of photosynthesis has been achieved, whereby it has become possible to demonstrate that the photoactivation process produces reducing systems that may be coupled with any of a large variety of redox systems, including many that have been shown to be important in respiration. In addition, studies in bacterial photosynthesis have revealed some details of the manner in which synthesis of cell constituents is affected by photoactivation processes. The observations involved are discussed, and their interpretations in terms of current concepts of the photosynthetic process are considered. It is noted that the central problem of photosynthesis—i.e., the nature of the biochemical mechanisms that intervene between the initial photochemical act and the appearance shortly thereafter of certain photosynthetic products—may be reformulated and rephrased in many ways, but that as yet a direct approach to the elucidation of this problem remains to be found.

The Production of Bacterial β-Glucuronidase and its Use for the Hydrolysis of Steroid Glucuronides

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Our interest in producing potent preparations of β-glucuronidase was prompted by the recognition of the need for mild yet effective methods for hydrolyzing the steroid conjugates that occur in urine, in other excreta, and in secretions.

Large amounts of β-glucuronidase are produced by *Escherichia coli* in the presence of menthyl glucuronide. Conditions for optimal production and activity of this enzyme have been determined, and some studies of its chemical and physical properties have been made.

The amount of total estrogen liberated from human pregnancy urine by this enzyme is as great as or greater than that obtained with acid hydrolysis. This indicates that the estrogen is conjugated to a very large extent with glucuronic acid.

Hydrolysis studies of the conjugated neutral 17-ketosteroids of the urine of normal men have shown that the major portion of this fraction is conjugated with glucuronic acid. This was not true in cases of adrenal tumors. It is believed that the distribution of the types of conjugates, as well as the total amounts of steroids, may be very important.

Since urinary corticosteroids are very labile to acid and heat, and since only a small fraction occurs in the free form, β-glucuronidase hydrolysis is important not only because it permits more accurate estimation of corticosteroid excretion but also because it gives better insight into the relative importance of urinary metabolites.

Incorporation of C^{14} Amino Acids into Peptides by Normal and Diabetic Rat Tissues

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In severe diabetes there is loss of tissue protein with negative nitrogen balance; insulin, on the contrary, favors uptake of amino acids by tissues. The present experiments were undertaken to determine how insulin influences peptide synthesis.

Rat liver slices or diaphragms were incubated in a physiological medium containing glycine-1-C^{14} or phenylalanine-3-C^{14}; the radioactivity incorporated into the peptide glutathione and into the total proteins of the tissues was measured.

Incorporation of glycine-1-C^{14} into glutathione of liver was greatly reduced in severe diabetes, as was the uptake of both amino acids into the protein fractions of liver and diaphragm. This depression of glycine-1-C^{14} uptake into glutathione remained relatively the same when the glycine concentration in the incubation medium was increased by a factor of forty. From this it is concluded that the net decrease in glycine-1-C^{14} incorporation in diabetes is attributable in large part to decreased peptide synthesis; a limited concurrent increase in protein breakdown in diabetes is not excluded.

Glutathione synthesis by diabetic liver was raised toward the normal level by addition of glucose to the incubation medium, and completely to normal by addition of both glucose and insulin; without adequate glucose in the medium, insulin alone had no effect on amino acid uptake by diabetic liver. The conclusion is that the influence of insulin on peptide synthesis in liver is exerted mainly via its favorable effect on glucose utilization. Whether insulin increases peptide synthesis by any other mechanism remains to be determined.

The Dynamics of Total Systems in Psychology and Biology

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The rapid rate of progress in the physical sciences and engineering has often been attributed to the effective use of mathematical methods. The possibility of using similar methods for theoretical treatment of the response systems of living organisms is not so generally acknowledged. Among the outstanding obstacles are the extreme complexity of biological systems and the lack of sufficient

information to permit writing the differential equations of a given system without extensive assumptions. The present paper outlines an approach that attempts to bypass these difficulties through the application of concepts derived from the engineering treatment of linear systems. Specifically, it attempts to derive mathematical functions to represent response systems from experimentally determined curves of the temporal response of the total system to specified forcing functions. It can thus be designated as an investigation of the dynamics of total biological systems, through a generalization of the meaning of dynamics in physics.

This approach is being carried out in two stages: (1) the development of methods for deriving system functions (transfer functions) from the response curves of biological systems, on the assumption that these systems are linear, and (2) the determination of signs of nonlinearity, from response curves, and the development of methods for taking account of them in the derivation of system functions. Illustrative records are presented of transient response curves of some psychological and biological systems, computer methods for deriving transfer functions, and some of the different types of nonlinearity observed. A graphical method for dealing with nonlinearity is briefly described.

A Differential Property of Plane Curves

P. Lanzano, *St. Louis University*

Given n plane differential elements of the second order E_i^2 $(i=1, \ldots, n)$ having distinct collinear centers, the dimension of the system of plane algebraic curves of order n (C^n) containing them will be

$$\nu = \frac{n(n+3)}{2} - (3n-\varepsilon) = \frac{n(n-3)}{2} + \varepsilon$$

$3n-\varepsilon$, $(\varepsilon \geqq 0)$, being the number of independent conditions imposed by the elements. As above system coincides with the one consisting of one curve (Γ^n) containing the elements together with $J^n \equiv \psi 3 \cdot C^{n-3}$ (ψ, line of the centers, C^{n-3} being arbitrary) whose dimension is $\nu = \frac{n(n-3)}{2} + 1$, so $\varepsilon = 1$; consequently, there must exist relationship among the coefficients of an analytic representation of the elements, which happens to be also sufficient for the existence of ∞^ν curves containing those elements.

Take $\psi \equiv y = 0$; any C^n having at the centers P_i $(\alpha_i; 0)$ the tangents $\tau_i \equiv \alpha_i - x + \beta_i y = 0$, will be (1) $\prod_1^n{}_i \tau_i = y^2$. C^{n-2} with arbitrary $C^{n-2} \equiv \sum_0^{n-2}{}_j \alpha_j x^j + y \sum_0^{n-3}{}_j b_j x^j + \ldots\ldots + h y^{n-2}$.

If (1) must contain the

$(i=1, \ldots\ldots, n)$, E_i^2's $\begin{cases} x = \alpha_i + \eta \\ y = p_i \eta + q_i \eta^2 + \ldots\ldots \end{cases}$

it must be:

$$\frac{q_i}{p_i^3} \cdot \prod_1^n{}_h (\alpha_h - \alpha_i)_{(h \neq i)} \sum_0^{n-2}{}_j a_j \alpha_i^j, \quad (i = 1, \ldots\ldots, n)$$

the consistency condition of this linear system in the a's can be written (2)

$$\sum_1^n{}_i \left(\frac{q_i}{p_i^3}\right) = 0,$$

which, in a Euclidean metric, becomes

$$\sum_1^n{}_i \left(\frac{K_i}{\sin^3 \varphi_i}\right) = 0,$$

K_i's being the curvatures of the elements and φ_i's the angles between $\tau_i = 0$ and $y = 0$. (2) is the sought relationship.

Radioactive Isotope Separation by Nuclear Recoil

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As observed earlier, the two radiobromine isotopes formed by neutron irradiation of the two stable isotopes of ordinary bromine suffer sufficiently different excitation so that the Szilard-Chalmers hot atom reactions are perceptibly different. For example, the irradiation of alkyl bromides followed by aqueous extraction shows that the 4.5-hr Br^{80} is more completely extractable than the 35-hr Br^{82}. The phenomenon of the hot atom radioisotope separation of bromine has been investigated in more detail, and has been found to occur only in the solid phase. No observable effect has been found in the liquid, even though the liquid be at the melting point of the solid. The effect of molecular structure has been investigated in a limited fashion and found to be very considerable.

These observations are discussed in the light of a possible explanation in terms of the Br^{80} possessing a higher recoil energy than the Br^{82}.

The Structure of Nucleic Acids: A New Method of Degradation

David Lipkin and Jonathan S. Dixon

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Various physical and chemical methods have been used in order to gain information concerning the structure of nucleic acid macromolecules. The chemical methods that have been applied are (1) acid-base titrations of various groups in nucleic acid molecules; (2) hydrolysis catalyzed by acid, base, or enzymes; and (3) "blocking" of active groups in the nucleic acid, followed by degradation to small, identifiable fragments.

A new degradative procedure being developed is the base-catalyzed methanolysis of nucleic acids. An advantage of this approach over hydrolysis is that one part of any bond which is broken in the reaction becomes labeled with a methyl group. Thus, if a phosphoric acid group is attacked which is esterified to only two nucleosides, a methyl ester of a nucleotide or a dimethylphosphoric acid should be formed.

The methanolysis is carried out under strictly anhydrous conditions, using methoxide ion as catalyst and methanol-formamide mixtures as solvent. Yeast ribonucleic acid, with one normal methoxide ion as catalyst, is completely methanolyzed in 1 hr at 65° C. After the reaction is complete, the resulting mixture is chromatographed on ion exchange columns. The chromatogram obtained contains about 14 peaks, in contrast to the chromatogram obtained on the same nucleic acid sample degraded by hydroxide-catalyzed hydrolysis.

The individual components of the chromatogram are analyzed for phosphorus, methoxyl groups, heterocyclic base, and vicinal glycol groups. An examination of the analytical data on the various fractions enables one to make deductions concerning the structure of the original nucleic acid molecule. The results obtained to date are discussed.

Organismal Differentials and Organ Differentials

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Varied series of transplantations of normal tissues and of tumors into the individuals in which the tissues originated, as well as into other individuals with different degrees of genetic relationship to the donor of the transplant, have led to the conclusion that each individual is characterized by an individuality differential, a substance which is the same in all or in the large majority of the organs, tissues, and cells of this individual and which differs from such substances in all other individuals. Corresponding substances characterize strains, races, species, genera, and classes of organisms. These various specific substances represent the organismal differentials. A piece of tissue or of tumor possessing a strange organismal differential, when introduced into a host, here calls for an antagonistic reaction on the part of the host cells, the most characteristic of which is the lymphocytic reaction which quantitatively indicates the degree of nearness or distance of the genetic relationship between host and transplant.

Within the same individual we may distinguish the different organs and tissues, such as kidney, liver, thyroid, skin, or cartilage, all of which possess the same set of organismal differentials, but differ in characteristics that are similar in the corresponding organs and tissue of all individuals, although in different individuals they possess different organismal differentials. These characteristics of various organs and tissues represent the organ and tissue differentials. In contrast to the organismal differentials, they do not as such elicit specific antagonistic reactions when transferred to other individuals. Both organismal differentials and organ differentials are associated in various ways in each individual, and they exert specific functions which vary in accordance with the prevalence of one or the other of these two types of differentials. It will be of interest to analyze in various vital processes the relative functions and preponderance of the organismal differentials and of the organ differentials, respectively.

The Quantitative Histochemistry of the Brain

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The structural complexity of the brain is such that interpretation of gross biochemical data seems almost hopeless. Simplification has been attempted through histochemistry. Of the several histochemical methodologies available that of Linderstrøm-Lang and his collaborators, which is capable of providing direct quantitative information and is otherwise advantageous, was adapted to the present purpose. The necessary changes included (*a*) the use of frozen-dried material and (*b*) a drastic reduction in the scale of analysis (10- to 10,000-fold), since with brain it is usually difficult to isolate regions larger than a few micrograms in weight that are sufficiently simple in structure to repay analysis for histochemical purposes. In order to obtain information of a broad metabolic and structural character, methods have been elaborated for the measurement of 10 different enzymes, 4 lipid fractions, 4 phosphorus fractions, riboflavin, and chloride on the necessary microscale (5 μg dry weight or less). In some cases the methods are sufficiently sensitive for the analysis of single large cell bodies. These are weighed directly on a simple quartz balance before analysis (weight, about 0.02 μg). Illustrative data are presented.

On the Mode of Action of Glycerol in Preventing Injury by Freezing in Embryonic Tissues of Chick

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Pieces of embryonic chick heart, previously immersed in glycerol, survive freezing in liquid nitrogen, as shown by their growth in tissue culture. To investigate the factors involved in that protective action, we determined what effect the immersion of the tissues for various lengths of time in various concentrations of glycerol may have in inducing longer or deeper supercooling, in preventing freezing, in reducing the amount of ice formed, and in permitting survival under these conditions. It was found that glycerol, besides dehydrating the tissues and lowering their freezing point, also delays the initiation of crystallization, retards the advance of the ice front through the tissues, and reduces the amount of ice formed at a given temperature. Furthermore, the treated pieces survived despite the formation of some ice in them. This latter finding indicates that the primary factor in the protective action of glycerol is not the prevention of, or the delay in, crystallization nor the lowering of the freezing point, but the ability of glycerol to reduce the amount of ice formed, an effect possibly attributable to some water-binding properties of glycerol.

Experimental Observations on the Role Played by Anaphylaxis in the Development of Renal Disease Following the Infusion of Mismatched Blood

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A series of dogs has been studied in regard to the production of renal disease following mismatched blood transfusions. Normal dogs can handle free dog hemoglobin in great quantities without evidence of renal tubular disease. Dogs normally hemolyze human blood as rapidly as it is infused and can dispose of the products of hemolysis without functional or pathological evidence of renal disease. If human blood is given to a dog about 4 weeks after a previous infusion, the dog shows a different type of response, characterized by cyanosis, collapse, vomiting, diarrhea, and shock. Subsequent to this infusion there is a persistent reduction in renal blood flow, with gradual recovery in most of the animals and a restoration of renal blood flow to normal values.

During the period of renal blood flow reduction there is elevation of the blood urea nitrogen. This returns to normal as the renal blood flow resumes normal values. If the renal blood flow has been reduced for a sufficient period of time, there is microscopic evidence of renal tubular disease, characterized by atrophy of the epithelium, dilatation of the tubules, and increase in interstitial fibrosis.

Reproductive Organs in Relation to Adrenal Cortex Secretions

Carl R. Moore, *University of Chicago*

Pathological conditions in the adrenal cortex of man

and of some strains of mice have indicated that the adrenal cortex secretes sex hormonelike substances that have profound effects, but it is less clear that normal adrenal cortex produces substances that have an effect upon the reproductive system.

Whereas an embryonic testis of the rat, transplanted into the walls of seminal vesicles of castrated adults, actively secretes male hormones that stimulate immediately adjacent seminal vesicle epithelium to an adult secretory type, similar transplantation of embryonic or postnatal adrenal glands fails to evoke a corresponding reaction; the adrenal cortex does not secrete male hormonelike substances in sufficient quantity to be detected by this most sensitive indicator method.

Cortisone acetate (Merck), a secretory product of the adrenal cortex, injected daily into rats—male and female, normal and gonadectomized, immature and sexually mature—fails to reveal a malelike or femalelike substance or a gonad-stimulating substance.

Purified adrenocorticotrophin (Armour), which stimulates the secretion of active substances by the intact adrenal cortex, likewise failed to produce responses in the various types of rats that suggested male or female hormone responses, or a sex gland-stimulating substance.

Adrenalectomy of sexually mature males and females did not produce detectable effects upon reproductive tissues. Adrenalectomy, coupled with castration, in immature males had but slightly detectable effects upon accessory reproductive organs above that of castration alone; the slight effects were associated with subnormal nutritive states.

Since positive effects attributable to normal adrenal cortex secretions did not appear, it is suggested that those effects associated with pathological adrenals may perhaps be due to an abnormal synthesis of adrenal steroids by the cortex, which yielded substances having effects ordinarily attributed to sex hormones.

Absorption of Radioiron from Foods

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Nutritional requirements for iron have not been established with precision, in part because it has been so difficult to determine how completely man absorbs the iron in food. The present study was designed to provide this information by measuring the assimilation of radioiron from foods by healthy human subjects, and by patients with hypochromic and pernicious anemia. The foods selected for study were those which could most easily be produced or grown so as to contain radioiron: eggs, chicken and rabbit liver, chicken muscle, mustard greens, and spinach. Results may be summarized as follows:

1. With very few exceptions, the absorption of Fe^{59} from these foods by healthy human subjects was less than 10%.
2. Iron-deficient subjects usually did not assimilate the food iron any more efficiently than did normal persons. Even when absorption was more complete, the difference was less striking than occurs after the feeding of inorganic iron salts.
3. Ascorbic acid and foods containing ascorbic acid enhanced the absorption of food iron. Other organic acids and reducing substances were less effective.
4. In patients with achlorhydria, it was not possible to increase the absorption of Fe^{59} either by therapeutic doses of 0.1 *N* HCl or by mixing enough 1 *N* HCl into the food prior to administration to lower the pH of the mixture to 1.5.

It is estimated that the normal adult male must assimilate between 0.5 and 1 mg iron/day in order to stay in balance. For the normal adult woman, the amount needed per day is probably 1.0–1.5 mg, depending on the menstrual loss of blood or the frequency of pregnancies. If only 10% of food iron is absorbed, it is clear that the recommended dietary allowances of 12–15 mg/day are none too high.

Studies of the Oxide Cathode

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Studies (1) of the decay and recovery of the pulsed emission of oxide-coated cathodes, (2) of the internal impedances within the cathode, and (3) of the effect of barium deposited on the surface of such a cathode by means of a mass spectrometer have led to a new physical model of the oxide-coated cathode. The salient features of this model are (1) the oxide cathode is an impurity semiconductor; (2) the donors are oxygen vacancies; (3) the donors are mobile—i.e., can diffuse and electrolyze readily at the normal operating temperatures of oxide cathodes, so that the internal conductivity of the cathode is a function of current. In this model, pulse decay results from donor depletion layer near the emitting surface of the cathode when high currents are drawn; recovery results from back diffusion of the donors. The model accounts for the anomalous Schottky effect of oxide cathodes and for other anomalous behaviors.

Hyperfine Structure in Paramagnetic Resonance of Free Radicals

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Washington University

Certain free radicals, in sufficiently dilute solution, exhibit a well-resolved hyperfine structure of the paramagnetic resonance line. The chemist is interested in this hyperfine structure because the magnitude of the splitting and the identity of the nucleus involved give information concerning properties of the wave function of the odd electron.

For the physicist, free radical systems provide examples par excellence of the phenomenon of exchange narrowing, and they serve as proving grounds for theories involving the interplay among exchange, magnetic dipole-dipole interaction between electrons, the electron-nucleus interaction responsible for hyperfine splitting, and thermal relaxation as mechanisms of line broadening. Experiments at Washington University raise questions as to the criterion for the appearance of hyperfine splitting, which does not always arise for dilute free radical solutions expected to show it, and as to the mechanism of broadening of the individual hyperfine structure components when they are resolved. These experiments have also led to the discovery of a free radical with static and resonant susceptibilities strongly suggestive of antiferromagnetic behavior.

The Sticking Coefficient of Nitrogen in Air and its Application to Low Pressure Measurement

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The sticking coefficient of air (mostly nitrogen) on

tungsten was measured in high vacuum by observing the time of deposition of a monolayer of the gas on the clean metal surface.

The *average* sticking coefficient α_{av} was measured as 0.14, and the initial sticking coefficient α_0 as 0.26. The latter value agrees reasonably with 0.3 obtained by Becker and Hartman. A new photoelectric measurement of α_0 is at present yielding a preliminary value of 0.39.

The measured sticking coefficients are applied in the measurement of low pressures. It is concluded that pressures below 10^{-7} mm Hg can be measured reliably.

Spectral Studies in the Far Infrared

K. S. Pitzer, W. D. Gwinn, J. L. Hollenberg, and C. Bohn, ***University of California, Berkeley***

A grating spectrometer has been built and operated satisfactorily in wavelength range 25–70 μ. The spectrum of water vapor was measured as a calibration and test. This spectral region contains important bands arising from bending vibrations of molecules. In some cases these frequencies can be found in the Raman spectrum, but in other cases the selection rules allow certain frequencies only in the infrared. Results are presented for 1,2-dichloroethane and several other halogen derivatives of ethane or ethylene. By completing the vibrational assignments for such molecules, it will be possible to draw valid conclusions concerning thermodynamic properties and interatomic forces within molecules.

Double Beta Decay and Theories of the Neutrino

H. Primakoff, ***Washington University***

The present theory of elementary particles is consistent with the existence of (*a*) neutrinos and their antiparticles—antineutrinos—or (*b*) neutrinos alone. In case (*a*), neutrino and antineutrino are in principle distinguishable through the sign of their magnetic moment—the expected magnitude of the moment is, however, extremely small. Experimentally, the question of the existence of antineutrinos may be studied by investigation of the phenomenon of double beta decay—the spontaneous disintegration of a nucleus of mass number A, charge number Z, into one of mass number A, charge number Z + 2. Theory shows that, if antineutrinos exist, (1) the two emitted electrons are accompanied by two emitted antineutrinos, and (2) the mean life of the decay is much longer than if antineutrinos are absent. Moreover, if antineutrinos do not exist, the two decay electrons are emitted unaccompanied by neutrinos, so that their total kinetic energy is the same for all individual disintegrations; the angular correlation function of the electrons has been calculated in this case and turns out to be $\sim 1 + \cos \Psi$ in the most readily observable situations.

The available experimental results still do not distinguish between the two major possibilities outlined; the preponderance of present evidence, however, seems to favor the existence of antineutrinos. A review of recent results is given and implications are drawn in addition regarding the probably related process of μ-meson decay.

The Propagation of Certain Short-Period Air Pressure Oscillations Recorded by the Macelwane Microbarograph

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St. Louis University **and** ***Parks College***

The investigation of 29 air pressure microoscillations of the impulse type with a period of 10–25 sec, as recorded by Macelwane Electromagnetic Microbarographs in a tripartite arrangement (dimensions: 45, 63, and 65 ft), at Florissant, Missouri (near St. Louis), during May and June 1950, reveals that these oscillations are propagated in the direction and with a speed that is of the same order of magnitude as the wind speed in the lower layers of the atmosphere, but not necessarily at the surface.

The Nuclear Interactions of μ-Mesons

R. D. Sard, ***Washington University***

Although the μ-meson has relatively weak coupling with nucleons and gives them but little energy in interacting, its appearance in the decay schemes of the π- and K-mesons makes it certain that a detailed knowledge of its nucleonic interactions will be of great value in finding a satisfactory theory for the whole family of unstable particles produced in high-energy nuclear collisions. A survey is given of present knowledge of the μ-meson nuclear interactions, in the course of which results obtained recently at Washington University are reported.

An Invariant Force Function in Muscle Activity

Gordon M. Schoepfle, William W. Sleator, Jr., and Arthur S. Gilson, Jr.
Washington University School of Medicine

The simple twitch constitutes the basic element of response of a muscle fiber to any single suprathreshold stimulus. The extent to which a muscle shortens transiently during a twitch against a constant load is decreased as the load is increased, but the time parameters of the contraction phase are very nearly independent of load or shortening in unfatigued muscle. If a small weight Δw is removed from the constraining load on the resting turtle neck retractor, the muscle will shorten through a length ΔL. The ratio $\Delta L/\Delta w$ is proportional to extent of shortening at any given time during the contraction phase, regardless of load or extent of shortening. The proportionality factor has the dimensions of a force and may be formulated as a force time function $f(t)$, invariant for all twitches against a constant load, regardless of load or extent of shortening.

Total tension is constant throughout the system in the case of this slowly acting muscle, but a structural reorganization of the system during activity may be thought of as leading to a redistribution of force components such that one of them becomes manifest in determining $f(t)$. These data are consistent with the "transmutation chain" theory of Buchtal and Kaiser, in which the fiber is assumed to consist of parallel molecular chains, each link of which exists either as an elongated element or as a shortened element. Some of the shortened elements may be fixated by a special substance liberated in constant amount during each twitch.

Chemical Control of Hypertension

Henry A. Schroeder, H. Mitchell Perry, Jr., and John D. Morrow
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Arterial hypertension is mediated by the interaction of at least two influences (1) neurogenic, dependent upon the vasoconstrictor mechanism of autonomic nerves; the chemical effector substances are acetyl choline for gangli-

onic transmission and *nor*-epinephrine for neuromuscular transmission; (2) nephrogenic, initiated by renal ischemia and dependent upon pherentasin and probably other primary amines in blood. The state of hypertension can be reversed, therefore, only by antagonizing both influences simultaneously. In more than 200 patients benefit has been accomplished.

Hexamethonium chloride is used to block ganglionic transmission. Given orally, it causes partial paralysis of autonomic nerves. 1-Hydrazinophthalazine is used to inactivate pherentasin; a carbonyl reagent, it apparently combines with the carbonyl group in pherentasin, as well as with other carbonyl compounds, such as pyruvic acid. It also has an affinity for sulfhydryl compounds both *in vivo* and *in vitro* and for heavy metals *in vitro*.

Many of the secondary effects of increased intra-arterial tension are reversed, especially congestive heart failure, low-grade renal insufficiency, angina pectoris, and the signs of the malignant stage. Rapid excretion or destruction of both drugs requires frequent administration.

The Significance of the Two Components of the Pain Path in the Surgical Relief of Disordered Sensibility

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To select the procedure offering the most promise of relief of unremitting pain is an aspect of neurosurgery requiring precise interpretation of the disordered sensibility. Among the conditions giving rise to such unremitting pain are neuralgias, causalgias, a phantom limb, tabetic crises, and malignant growth. Procedures available are paravertebral nerve block, section of nerve roots next the spinal cord, section of pain tracts in the cord, and frontal lobotomy. The character and distribution of the pain indicate the procedure of choice.

Recent studies by Bishop and Landau support prior evidence that there are two kinds of pain. Pricking pain, which is conducted centrally from the skin over small myelinated peripheral axons with fusion at 30/sec stimulation, may be blocked differentially in man by a pressure cuff about the arm. After blocking, a burning pain of long latency can still be elicited, with fusion at 3–5/sec. This pain is believed the same as that shown by Gasser and Hughes to be conducted over nonmyelinated axons, and is closely akin to that identified by patients as unremitting pain.

In our study we have used the conventional procedures of cutaneous stimulation on patients, studying the two pain components before and after section of the pain paths in the spinal cord. Our present results indicate that both pricking and burning pain follow the same route to higher centers. Other evidence from experimental animals suggests that the two pain components also relay in the same region of the thalamus.

The results are considered in the light of past contributions by Head and by Trotter and Davies.

The Nature of Kinetic Barriers in Aqueous Reactions

Philip A. Shaffer
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In a search for clues to the nature of factors that restrain the spontaneous velocities of many dynamically permissible reactions (''kinetic barriers''), the writer examined some years ago a number of oxidation-reduction reactions between reversible ionic couples. In the form of galvanic cells these reactions exhibit no evidence of ''latent resistance'' to reaction rate, except that inherent in the ''electro-chemical apparatus;'' but in homogeneous solution some are slow or unreactive in the absence of catalysts or mediators. Examination of the latter group revealed several factors reported briefly as hypotheses in 1933, 1936, and 1939.

More recently this study has been resumed. It now seems probable that at least three distinguishable factors may be identified.

1. Like sign of electrical charge of reactants (coulombic repulsion) may alone suppress reaction when $-\Delta F$ is relatively low.
2. The ''equi-valence-change'' principle (suggested in 1933) may alone suppress reactivity. Both (1) and (2) may be mediated in several ways.
3. In many cases participation of *both* ions of *water* —the ionization of $(H_2O)_n$—seems essential. This is perhaps a major factor in the ''energy (heat) of activation'' as measured by temperature coefficients.

Data for a few reactions are presented to illustrate the separate influences of these factors controlling reaction rates; they may be dominant factors of more general applicability to this complex problem.

The Electroyltes of the Endolymph and Perilymph

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By using a special surgical approach it is feasible to obtain about 0.5 mm^3 (.0005 ml) of endolymph and 1 or 2 mm^3 of perilymph from the ear of a guinea pig without appreciable contamination or evaporation. These fluids, together with spinal fluid and blood plasma, were analyzed for Cl, Na, and K, using analytical procedures that had to be developed specifically for this purpose because of the minute amounts of fluid available. Perilymph proved to be nearly identical with spinal fluid in regard to the 3 anions measured. Endolymph, however, was found to have a K concentration 20 or 30 times that of perilymph (140 mEq/l compared to 6) and a Na concentration only a tenth as high as perilymph or spinal fluid (15 compared to 150 mEq/l). The Cl of endolymph is 90% of that in perilymph and spinal fluid. Endolymph has thus proved to be unique among known extracellular fluids, and it seems possible that its unusual electrolyte pattern is implicated in the function of the special sense organs concerned.

Properties of Myelinated Fibers in Sciatic Nerve and in Spinal Cord (Frog) as Examined with Microelectrodes

Ichiji Tasaki, *Central Institute for the Deaf*

This investigation aims to clarify the properties of the myelinated nerve fiber by introducing capillary microelectrodes into individual nerve fibers. Action potentials were recorded through such a microelectrode inserted in various parts of an isolated nerve fiber and were compared with the action current records taken simultaneously from the same internode of the fiber. With the electrode

inserted in the innermost layer of the myelin sheath but still outside the axis cylinder, action potentials of 1–30 mv were observed, but there was no measurable resting potential. Conduction across the impaled region was not hindered by this procedure. When the microelectrode was introduced into the axis cylinder, either in the internode or at the node, both resting and action potentials were observed. Both were generally less than 30 mv. The action currents indicated that the response of the fiber was reduced by the injury caused by introduction of the electrode. Conduction across the impaled internode failed within 1–10 min after the appearance of a resting potential had indicated that the electrode had entered the axis cylinder. Conduction could be restored by passing an inward-directed electric current through the internal electrode.

Isolated single fibers were excited by brief pulses of current applied through microelectrodes at various parts of the fiber. The surface membrane at the node of Ranvier is the only place where stimulating (outward-directed) current can induce a response.

Action potentials from individual fibers in the spinal cord were recorded with microelectrodes inserted into individual fibers. By applying polarizing currents through such an internal electrode, physiological evidence was secured for the existence of the nodes of Ranvier in the fibers in the dorsal funiculus.

The threshold for a single fiber in the dorsal funiculus was measured by observing the responses in single (afferent) fibers in the muscle nerve. The threshold varied greatly from point to point along the course of the fiber. The nodes of Ranvier of the fiber could be located by this method.

The Composition of the Stony Meteorites and the Abundances of the Elements with Particular Reference to Iron

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University of Chicago

The iron and achondritic meteorites represent highly differentiated materials, and unless their origin is well understood they cannot be used for determining the composition of cosmic matter. The achondrites can be classified into two groups—namely, those having a composition similar to basalts and those having silicates of the same composition as the silicate phase of chondrites. The latter appear to be overheated chondrites. The chondrites, because of their thoroughly mixed-up structure, may represent an average sample of the colliding asteroids that produced them. The chondrites, on the basis of selected analyses, contain two prominent groups having markedly different amounts of total iron, so that some fractionation process has partially separated the silicate and iron fractions, just as has occurred in the case of the terrestrial planets. Possible separation processes are discussed. It is concluded that the lower abundance of iron is more probable, and from our data iron has an atomic abundance of ~ 0.6 that of silicon.

On the Theory of Bernoulli Numbers

H. S. Vandiver, *University of Texas*

The numbers of Bernoulli, which are used in many parts of mathematics, consist of a certain infinite set of rational numbers, which numbers are usually designated by B_k, where k ranges over the set of positive whole numbers, and they may be conveniently defined by a certain algebraic recursion formula. For more than a century mathematicians have been studying the arithmetical properties of the numerators and denominators of the B's; some of the principal results that have been discovered along this line, particularly several of the recent ones, are explained. Some of these turn out to be related to a few of the deepest outstanding questions in the theory of numbers.

Gene Action in Connection with Growth and Development

F. W. Went, *California Institute of Technology*

Theories on gene action are largely based on their effects on biochemical synthesis. Work, particularly on adaptive enzymes, indicates that genes initiate but do not quantitatively control such syntheses. Yet, for the genetic control of growth and development, mechanisms are indicated that control growth to within a fraction of 1%. Reproducibility of growth under controlled conditions is much greater than originally suspected and requires special consideration in connection with genetic control. One mechanism that satisfies the requirements for quantitative control of growth, with even self-regulatory features, is a diffusion process limiting nuclear-cytoplasmic interaction. This idea is developed in connection with some new facts about plant growth.

Mechanism of Adrenal Hyperplasia and Androgenicity

Emil Witschi, *State University of Iowa*

Adrenal hyperplasia, often combined with virilism, is a relatively frequent morbid condition in young men and women. For an analysis of its etiology it is fortunate that a similar adrenogenital syndrome can be experimentally induced in frog larvae, through treatments with estrogenic steroid hormones. By high dosages the adrenal tissue is increased tenfold, and the gonads of genetically female larvae are transformed into hermaphrodite glands or testes. However, the masculinization does not represent a direct response of the sex gland to the estrogen, but is mediated through the adrenal glands.

Moreover, if larvae were hypophysectomized before initiation of the hormone treatment, the adrenals do not enlarge but remain just as underdeveloped as in hypophysectomized controls. A complicated hormonal reaction chain is thus revealed, of which even now we know only some major links. In general we recognize the following sequences: The high estrogen concentration apparently depresses the gonadotropic component of the hypophyseal function complex, which in turn leads to an increase in ACTH production and subsequent adrenal hyperplasia. It is not known whether a hyperplastic adrenal is hyperfunctional in a general sense or whether some of its minor capacities increase disproportionately; but the experiments show that at a certain level the hormonal secretions reach an androgenic threshold value, which in frogs is sufficient to dominate even the sexual differentiation of the gonads.

A brief discussion of the mechanism of hormonal reaction chains is given.

Ion Exchange between Alkali Halide Crystals under the Fusion Temperature

Lyman J. Wood, *St. Louis University*

In the past fine powders have been largely used in studies of reactions between solids. Several alkali halides can now be had in the form of large crystals, and the investigation of such problems as (*a*) the thickness of the initial reaction layer, (*b*) the rate of penetration of ions into solid crystals, and (*c*) ion exchange at the surface can now be greatly simplified. Because of its unique character the reciprocal system $RbCl + KBr \rightleftharpoons RbBr + KCl$ was selected for detailed study. It has now been shown that this reaction occurs at temperatures far below the fusion point. By the use of a macrocrystal of potassium bromide reacting with fine rubidium chloride powder, at below fusion temperatures, it has been possible to show that (*a*) rubidium chloride vapors react rapidly with the surface of the potassium bromide, (*b*) after the comparatively rapid initial surface reaction the rubidium and chloride ions continue to penetrate into the potassium bromide crystal but at a decreasing rate, (*c*) all the potassium, rubidium, bromide, and chloride ions are contained in one solid solution. The formation of this sort of solution is not only interesting in itself but makes possible a subtle combination of the refractive index and x-ray methods of analysis. By a combination of these two analytical methods it was possible to distinguish between ion migration through the crystal and transfer in the vapor phase along accidental faults. Rates of penetration into the crystal were found to decrease greatly as the temperature decreased further below the fusion point.

Surface Phagocytosis

W. Barry Wood, Jr., and Mary Ruth Smith
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Man's ability to recover from acute bacterial infection depends in large measure upon the leucocytes that are formed in his bone marrow and circulate in his blood. In the presence of infection these cells pass through the walls of the blood vessels and accumulate at the site of bacterial invasion. There they phagocytize the bacteria and destroy them. Certain microbes that cause serious infections, however, are able to resist ingestion by virtue of outer capsules that protect them from the phagocytic cells. If the host is able to survive the infection for 5 or 6 days, his tissues will make antibodies which react with the capsules of the bacteria and render them susceptible to phagocytosis. Since antibody production is a slow process, survival in the early stages of infection depends upon destruction of the bacteria in the absence of antibodies. Leucocytes have been shown to destroy encapsulated microbes in the crucial preantibody stage of infection by a process referred to as "surface phagocytosis." Its occurrence *in vitro* and in the blood stream of rabbits with bacteremia has been recorded by motion picture photography.

A Biometric Analysis of Natural Selection in *Asclepias tuberosa*

Robert E. Woodson, Jr., *Washington University*

Asclepias tuberosa, popularly known as butterfly weed and orange milkweed, consists of four subspecies, two of which are allopatric in the eastern United States. Of particular interest are the remaining two subspecies, which apparently are sympatric and with a common center of distribution in the Ozark highlands of Missouri. The constituent populations radiate roughly in a vast semicircle from near Toronto on the northeast to Monterey on the southwest and to the Black Hills on the northwest; both subspecies merge toward the southeast with the allopatric eastern subspecies.

The populations of the Ozarks, which are typical of ssp. *interior*, were first distinguished from those of the far periphery, typical of ssp. *terminalis*, through the shapes of their leaf bases, which are cordate and more or less cuneate, respectively. In the intervening area the population means of the leaf bases gradually merge from one to the other extreme, creating a striking series of concentric isophenes when plotted upon a phenocontour map.

Biometric analysis indicates that the two subspecies are interfertile and that ssp. *interior*, the younger of the two, is penetrating and obliterating the surrounding populations of the older ssp. *terminalis* through introgressive hybridization. The secret of the genetic success of ssp. *interior* apparently is its associated reproductive potential and general vigor, which are considerably greater than those of ssp. *terminalis*.

The implementation of natural selection by introgressive hybridization, termed "sabinism," is discussed briefly.

Electric Response of the Retina to Change of Color

Alexander Forbes and Sylvia Burleigh
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Onset and cessation of illumination both evoke electric responses in vertebrate retinas. If, without change in intensity, shift from one color to another evokes electric response, it relates the potential to color discrimination. A beam-splitter brought two light beams to coincidence on the retinas of frogs or turtles. Interference filters delivered nearly monochromatic light—red, yellow, green, or blue. A beam-shifting shutter made the transition between colors with minimum flicker. Intensities were balanced with rheostats in the lamp circuits. With all six combinations of these colors the shift evoked electric responses; no balancing of intensities abolished it. The response in long-wave-to-short-wave shift differed from that in the reverse shift. In the dark-adapted frogs, when the beams were equivalent as judged by the "b-wave" (positive), the preceding "a-wave" (negative) was absent or small and brief in the short-to-long-wave shift, larger in the reverse shift. The b-wave showed longer duration in short-to-long-wave shift than in the reverse. Frogs have both rods and cones whose differential involvement might explain the differences in responses to different colors. Yellow and blue with light-adapted frogs showed reversal of the above differences. Turtle retinas (only cones) showed shift responses with less difference between short-to-long and long-to-short shifts than in the frog. The slight differences more nearly resembled those in light-adapted than in dark-adapted frogs. Rod-cone differential may therefore explain some, but not all, features of the responses.