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Role of the Spleen and Nonsplenic Sites in Antibody Formation

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Further studies have been made on hemolysins (determined photometrically in 50% units) in rabbits following intravenous injections of sheep erythrocytes. The relative importance of nonsplenic sites in forming antibody increases with the amount of sheep cell antigen injected, as indicated by a comparison of daily and peak titers in intact and splenectomized animals. Furthermore, the effects of splenectomy are reversed in multiply- as contrasted to singly-injected rabbits. Thus, splenectomy resulted in a decrease to about 20% in the peak titer after a single intravenous injection of 1.25 ml of 1% sheep cells, whereas it resulted in an increase to 300% after 10 similar injections. The most likely explanation of the lower production of antibody in multiply-injected intact animals as compared to splenectomized ones is that the spleen is in a refractory phase, but continues to remove antigen from the blood before it reaches nonsplenic sites. After a single antigen injection, the spleen forms most of the antibody and abruptly passes into an inactive phase partly due to lack of antigen. After intensive antigenic stimulation, the spleen forms about 3 times as much antibody and then enters a refractory phase during which it fails to respond to frequently repeated antigen injections. During the same intensive immunization, nonsplenic sites in intact animals may produce 20 times as much antibody, and in splenectomized animals even more.

Locomotion of *Chaos chaos*, the Giant Ameba

Warren H. Lewis, *The Wistar Institute*

Chaos has two gel layers, a complete thin outer plasmolemma and a thick plasmogel which encloses, except at pseudopod tips, fluid plasmosol. Gel layers always exert contractile tension. Contractility, not elasticity as is usually assumed, is the motive force of ameboid movements and plasmosol streaming. Contraction of posterior plasmogel forces plasmosol forward against weak plasmolemma pseudopod tip and expands and advances it. Tail is pulled forward and anterior plasmogel backward. Gelation on inner aspect of plasmolemma tip prevents its rupture. As posterior plasmogel contracts it solates into plasmosol. Anteriorly plasmosol deflected by the plasmolemma tip to the sides gels and prolongs gel layer forward faster than it is pulled backward. This is the sol-gel cycle—contraction and solation at posterior end, advance and gelation at anterior end. After pseudopods have advanced for varying distances free in the surrounding water, they may retract or bend to the substratum and become temporarily adherent to it by their tips. Old attached pseudopods are released, retract, and eventually become part of the irregular tail end. There is an irregular succession of varying numbers of new advancing and retracting pseudopods. Adhesion is essential for locomotion. Without it the sol-gel cycle (fountain streaming) continues, but the ameba does not migrate. This is illustrated by scenes showing an ameba with a large persistent anterior vacuole. Behavior of charcoal granules indicates that they are pulled along by an invisible layer of secreted slime and not, according to the usual concept, by plasmolemma.

The Red Blood Cell as a Chemical Reagent

M. H. Jacobs, *University of Pennsylvania*

Special properties of the red blood cell (which are discussed) permit its use both as a simple chemical reagent and as an indicator of the progress and end points of a variety of chemical reactions. Changes of shape of the red cell affect the optical properties of its suspensions in a manner that is visible to the naked eye and may readily be photographed. Such changes may conveniently be produced by as little as 0.01 mg of certain surface-active substances. An impurity in so-called chemically pure sodium chloride, later shown by Ball to be silver, was discovered by its characteristic hemolytic action on the red cells of certain fishes. The nature of this action has been further investigated. A highly specific effect on the permeability of human red cells to glycerol permits the detection of copper at a concentration equivalent to 1 mg in more than a barrel of solution, and quantitative measurements of actual amounts of less than 0.1 γ. The characteristic type of permeability of the red cell to ions furnishes a test for ammonium salts which is positive and quantitatively useful at concentrations as low as 0.00003 *M*. Tannic acid at very high dilutions changes the permeability of red cells to anions in a way that can be used for the indirect determination of minute amounts of substances such as proteins and organic bases with which it combines. Other examples involving similar principles are known, and the list is doubtless capable of extension.

Induction of Mutations in *Escherichia coli* by Manganous Chloride

M. Demerec, *Carnegie Institution of Washington*

Tests with *E. coli*, in which induced mutants involving phage resistance and streptomycin dependence were studied, revealed that $MnCl_2$ is a very potent mutagen. It was found that the degree of mutagenic effect of $MnCl_2$ is greatly influenced by the condition of the treated bacteria. Its effectiveness is reduced if before treatment the bacteria are washed in water. Washing in a hypotonic solution of NaCl, KCl, $CaCl_2$, sodium lactate, or sugar (lactose, dextrose, sucrose) also decreases the effect, whereas washing in a hypertonic solution of any one of these chemicals increases it. The effect is slight if the bacteria are grown anaerobically, or if they are treated when in the growing stage. Magnesium suppresses the action of $MnCl_2$, which is also affected by the temperature during treatment, the concentration of $MnCl_2$, and the duration of treatment. The mutagenic effect of $MnCl_2$

cannot be reversed by subsequent washing. Results obtained so far indicate that it depends on the intake of the chemical by the treated cells, and on the amount that is bound in a certain way by these cells. Identical treatment with $MnCl_2$ may induce from 0 to 2×10^4 mutants per 10^8 treated bacteria, depending on the condition of the bacterial cells.

Effect of Total Removal of Liver on Free Amino Acids of Plasma

Frank C. Mann and Associates, ***Mayo Foundation***

The objective of many of our investigations on the liver is to seek a method for quantitating one or more functions of the organ which could be used clinically. The technique of paper chromatography offered a new tool with which to continue such investigations, because the free amino acid content of blood, tissues, and urine increases after total removal of the liver.

In the present investigation the liver was completely removed from dogs by an appropriate technique, and the necessary amount of glucose was injected continuously. Specimens of blood and urine were obtained before operation and at the end of the experiments, which occurred 15–30 hr after hepatectomy. A comparison of the chromatograms of the specimens indicated an increase in the concentration of many amino acids in the plasma after total hepatectomy. Increases in the concentration of these amino acids were not found in control animals receiving similar injections of glucose. The relative distribution of individual amino acids was not greatly altered, and the increase occurred in both the essential and nonessential amino acids. No amino acid or its derivative appeared to increase predominantly or at the expense of other amino acids.

Rhodopsin and Visual Excitation

George Wald and Paul K. Brown, ***Harvard University***

Light striking the retina of the eye bleaches the pigment of the rods, rhodopsin. This is a complex process, initiated by a photochemical reaction, followed by dark changes. Ultimately it breaks rhodopsin into a mixture of the protein, opsin, and the yellow carotenoid, retinene. Somehow this process, probably in its first stages, leads to a nervous discharge which, transmitted from neurone to neurone to the brain, ends in the production of visual sensations. At all levels the response is manifested by electrical changes—action currents in the retina, optic nerve, and brain. Each of these structures presents in turn the fundamental problem of excitation—how a stimulus evokes the electrical changes that constitute the response.

We have found that the bleaching of rhodopsin by light exposes new sulfhydryl groups on opsin, two such –SH groups for each molecule of retinene liberated. The sulfhydryl group is highly reactive; it is weakly acidic, readily binds metal ions, and is a strong reducing agent. Through all these properties it can be made to yield electrical effects.

For example, a rotating platinum electrode in a solution of silver nitrate, connected through a salt bridge to a mercury-mercuric iodide half-cell, generates an electric current proportional in strength to the concentration of silver ions. This arrangement can be used to measure sulfhydryl groups, for the latter by binding silver ions lower the current (Kolthoff and Harris). If rhodopsin is titrated with silver ions in the dark in such a cell, the current remains minimal until all –SH groups are removed. On adding further silver ions, the current rises. On bleaching the rhodopsin with light, new –SH groups appear which remove silver ions, and the current falls again. In this way the bleaching of rhodopsin results directly in an electrical variation.

We are exploring potentiometric and polarographic variants of this phenomenon, and possibilities of casting it into forms which mimic physiological systems. In the liberation of reactive chemical groups by a stimulus, and the ionic rearrangements which follow, it may provide a general model of the excitation process.

Replacement of Thyroxin by its Nitro Analogue (3,5,3′,5′-Tetranitro Thyronine)

Fritz Lipmann and Charles H. DuToit
Massachusetts General Hospital

The nitro analogue of thyroxin which, for a long time, we had hoped to test was made available to us through the generous cooperation of B. A. Hems, of the Glaxo Laboratories Ltd., of Greenford, Middlesex, England. It contains nitro groups in the same positions on the thyronine skeleton, where the product of the thyroid gland contains iodine. The compound was tested on thyroidectomized rats. The animals were used when their growth had stopped and a low metabolic rate had developed. They showed thyroid-deficiency signs, including scaliness of tail, caked eyes, and a rough fur. On injection of 25 mg of tetranitro thyronine, in a single or a once-repeated dose, the growth resumed for 2–3 weeks. The deficiency signs receded, and the metabolic rate rose to normal levels. One animal, after receiving 25 mg twice, showed a transient exophthalmic reaction. The nitro analogue appears to be about 1/100 as active as the iodothyronine (thyroxin). Activity of the nitro compound suggests that the specific action of the hormone may depend on a strong negativity of the substituents on the phenolic ring system, rather than on their specific halogen nature. Other studies on the metabolic action of the thyroid hormone are in progress in this laboratory, and are discussed briefly.

The Role of Electroosmosis in Living Cells

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The possible role of electroosmosis in the movement of water through living cells has been tested in *Nitella*, where the magnitude of bioelectric potentials is known, definite voltages can be applied to known cell surfaces, and current densities calculated.

In the range of normal bioelectric potentials (up to 100 or 200 mv), no appreciable movement of water is produced through the cell. This is true up to considerably increased applied potentials (e.g., 1.5 v), which are still tolerated during brief exposures. Current densities may be 0.05 ma/cm² of surface.

With large applied potentials (5–40 v) giving current densities up to 5 ma/cm² of cell surface, larger effects are produced. In some cases differential damage occurs, allowing intake of water (probably by osmosis) at the less damaged end of the cell. This continues when the current is stopped or reversed, but disappears as the cell

dies. It can be greatly decreased by bathing the cell in an isotonic nonelectrolyte (e.g., mannitol).

In a completely dead cell, true electroosmosis appears as the salts diffuse away, if sufficiently large currents are passed.

It is concluded that electroosmosis is a minor factor in the movement of water in the normal cell.

Blood-Group Specific Hemagglutinins from Plant Sources

William C. Boyd, ***Boston University***

For a long time it has been known that agglutinating substances could be extracted from certain seeds, for example, the castor bean. These extracts agglutinated bloods of a wide variety of species. Later, Landsteiner showed that some extracts exerted a more powerful action on the erythrocytes of some animal species than on those of others. A degree of species specificity was thus demonstrated. During World War II the present author and, independently, Renkonen demonstrated that extracts of certain seeds, especially certain beans, showed a specificity even within a single species. For example, extracts of certain varieties of Lima beans agglutinated only blood cells of groups A and AB, being thus specific for the blood group A antigen; others agglutinated group B also. Some agglutinated none of the four blood groups. Extracts of another species, the scarlet runner bean, agglutinated bloods of all four groups. Some extracts allowed the subgroups of A and AB to be noted, others did not. It is evident that theoretical importance attaches to a study of the chemical nature of these plant agglutinins, to methods of preparing them, and to the question of their mode of inheritance in the plants. Also, if a specific plant B agglutinin, for example, could be found, or separated from an AB agglutinin by genetic methods, or possibly even if this could not be done (since in the USA anti-A is the scarce agglutinin in the population), these reagents might have practical importance, especially as they are very cheap to prepare.

An Analysis of the Responses of Plants to the Length of Day

James Bonner, ***California Institute of Technology***

Growth and development among many species of plants are directly influenced and in fact controlled by the relative lengths of day and night—a phenomenon known as photoperiodism. Although the responses of plants to this environmental factor of photoperiod include its effects upon vegetative growth, a still more spectacular response and one that has undergone more investigation is that of the initiation of the flowering condition. Thus, in one category of plants, that of the short-day plants, the flowering condition is initiated only when the plant is grown on a regime in which the nights exceed a particular critical length in their duration. Flowering in these plants is then a response to the length of the dark period. Under certain circumstances, however, interruption of the dark period by a single light flash may result in total suppression of flowering.

Much has been learned in the past about the kinetics of the photoperiodic process as well as of the anatomical changes which accompany floral differentiation, but it has only been recently that any description of the physiology of the photoperiodic process or attempt to separate the over-all process into its constituent partial processes has been possible. In short-day plants, the initiation of floral primordia is mediated by the leaves, the organs directly sensitive to photoperiod. Under the influence of a long dark period or repeated dark periods, the leaves produce and export to the buds a substance or substances which cause flower bud initiation. Although the dark process is inhibited by an interruption with even the minutest quantities of light, nonetheless the dark period, to be an effective one, must be preceded by a light period of suitable duration and of relatively high intensity. These processes may be summarized as follows:

Process 1	*Process 2*
high intensity → light process	dark process → (light inhibited)
Process 3	*Process 4*
synthesis → of flowering substance	export of flowering substance → Flower buds

Present experimental evidence indicates that Process 1 may be that of photosynthesis, since the requirement may be met by supplying the plant with sucrose. Process 2, the dark process, appears to bear a relation to the metabolism of auxin, the plant growth hormone, in the leaf. Thus, this process is suppressed by the artificial application of auxin to the leaf. The flowering substance itself (or substances themselves) is of an unknown nature and can be at present described only in terms of its movement within the plant and from plant to plant.

Variability in Menstrual Cycles

George W. Bartelmez, ***Carnegie Institution of Washington***

The tradition of a 28-day menstrual cycle still persists, although the normal range is from 3 to 5 weeks in the human species and also in the rhesus monkey. Cycles of the same length may differ radically from one another. Variability is inevitable in a cycle controlled by a system of balanced endocrine forces, since a fluctuation in any one changes the configuration of the whole. Such changes tend to modify the time relations of the component "phases" of the cycle, as well as its total length. The ultimate receptors (target organs) reflect changes in hormonal balance. The varying concentration of hormones in consecutive cycles is manifest especially in the graded series of responses of the Hartman staircase. In addition the susceptibilities of a target organ may vary. Thus the threshold for response in the uterine mucous membrane differs in various areas of the same organ, as well as in different individuals. Conditions in preceding cycles may also influence the appearance of a target organ.

Adequately documented and normal human material is extremely rare. In a series of 197 selected specimens from rhesus monkeys the uterine mucosae have been grouped primarily on the basis of the controlling ovarian conditions. These groups are not homogeneous. There are differences in the reaction of the several tissues of the mucous membrane; the gland cells may show the characters dominant in one group, whereas the intervening connective tissue resembles that of another group. There is a definite rhythm in female primates. It is not a rhythm of gears and levers, but that of a living, pulsating organism attuned to various influences, both internal and external.

Differential Growth Response of Nerve Cells to Thyroid Hormone

Paul Weiss and Fiammetta Rossetti, *University of Chicago*

The physiological basis of the differential activation of specific patterns of nerve cells by hormones (e.g., in sex behavior), is still obscure. Evidently, certain neuron combinations are singled out to the exclusion of others, which could be due either to differential accessibility of the hormone or to specific constitutional response differences among various kinds of neurons. The following experiments strongly support the latter alternative. They deal with the transformation of the larval into the metamorphosed brain in the frog under the action of the metamorphosing hormone of the thyroid.

A pair of large cells in the larval hindbrain (Mauthner's cells), concerned with swimming, disappear after metamorphosis from amidst a group of persisting neurons. This regression is not caused by peripheral changes (loss of tail), since mere tail amputation or high transection of the spinal cord fails to evoke it. Presumably the cell bodies react directly to the metamorphosing hormone. To test this assumption, fragments of rat thyroid or thyroxin-agar were implanted near the hindbrain of immature tadpoles according to Kollros. Within a few days, marked local changes developed in the adjacent hindbrain. Mitoses in the ependyma increased by more than 500%. This stimulation extended far into the spinal cord. The cells and nuclei of the gray matter gained in size, the nuclear volume increasing to an average of 182% with fresh gland, and 165% with thyroxin. In sharp contrast to this growth stimulation, Mauthner's cells, interspersed with the stimulated cells, atrophied, losing *ca.* 30% of their cytoplasmic volume and 20% of nuclear volume. Mauthner's cells thus reacted in a sense opposite to that of other nerve cells at the same level. The reactions reached a peak about the third day after implantation, then subsided with the disintegration and hormone depletion of the grafts. No similar effects were observed in control experiments with fresh parotid glands or boiled thyroids as grafts.

The experiments thus prove that thyroid hormone affects the growth of nerve cells directly, but acts differentially and even antagonistically on different types of neurons, revealing thus a preformation of the response pattern in latent constitutional differences among the different units of the neuronal population.

Quantitative Cell Morphology

Paul Weiss and Beatrice Garber, *University of Chicago*

Cell forms are still largely described pictorially, e.g., as spindle-shaped, arborized, disc-shaped, crenated, etc. Physiological and pathological cell transformations are dealt with in similar terms. The present paper reports a first attempt to reduce such static descriptions to objective, quantitative, and relatively precise terms with reference to the formative and transformative processes.

A general dependence of the morphology and motility of chick mesenchyme cells in tissue culture upon the physical constitution of the culture medium (blood plasma) had previously been established (Weiss 1929). On the assumption that the deviation of a free cell from spherical shape depends on (*a*) adhesion and extension of surface protoplasm along fibrous strands in the medium, (*b*) hydrodynamic competition for further protoplasmic inflow among these protrusions, (*c*) cohesive and elastic properties of the cell, and (*d*) rate of protoplasmic motion, it can be predicted that the shape of a cell (e.g., number of poles), the ratio of length to width, the proportions of the nucleus, the rate of migration, and related features will be direct functions of the texture of the medium (density of fibrous strands and frequency of intersections). Experiments were therefore set up in which the texture of the blood plasma clot was methodically varied by varying either plasma concentration over a range from 10 to 90% or pH from 5.6 to 8.0, with other conditions being kept constant.

Measurements on 3,764 cells from standard fibrocyte cultures plotted against concentration or pH gave smooth curves of the predicted trend. With increasing concentration or decreasing pH (increasing coarseness of the fibrin net), the number of cell processes decreased (the ratio of bipolar "spindle" cells to multipolar "stellate" cells increased), and the ratio of length over width for both cell body and nucleus increased. Rate of movement increased at first, but tended to become constant above the 50% concentration. The results indicate that an objective quantitative cell morphology is feasible and conducive to better understanding of cell morphogenesis.

Migratory Behavior of Embryonic Pigment Cells Isolated Singly or in Small Groups *in Vitro*

Victor C. Twitty, *Stanford University*

The cells responsible for the pigmentation of the vertebrate skin and its derivative structures originate from the "neural crest" of the embryonic spinal cord and attain their eventual widespread distribution in the body by ameboid migration from this source. Earlier studies by the author on the migratory behavior of populations of embryonic pigment cells *in vitro* strongly indicate that their dispersion from the neural crest is a response to chemical excitation exerted mutually by the developing pigment cells. This interpretation is substantiated by the present study, in which neural crest cells were isolated singly or in small groups of two or more in capillary tubes of very small bore. Single cells, although surviving and differentiating normally, remain essentially stationary, whereas cells isolated in pairs or in small groups move away from one another, often for considerable distances, and tend to assume a uniform spacing within the tube. The results establish definitely that these movements are in response to mutual stimulation, and the strongly directional character of the migrations points clearly to diffusion gradients as the motivating factors.

Resumption of Ovulation by Mouse Ovaries Following Implantation in the Spleen

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The work of Biskind and Biskind with rats and of Gardner and Li with mice showed that the ovary, when removed from its normal site and transplanted in the spleen of a gonadectomized animal, became malignant after a prolonged sojourn.

The present series of experiments repeats the basic technique of Gardner and Li. It uses inbred strains of mice. It adds to the former technique the removal of the transplanted ovary from its splenic site and its retransplantation in the ovarian capsule of gonadectomized females. The genetic theory of transplantation is used to

select animals for retransplant hosts in such a way as to give optimum conditions for successful growth.

The objects of the experiment are as follows:

(1) To determine whether retransplantation is successful and will be followed by resumption of normal ovulatory function.

(2) To determine the maximum duration of splenic sojourn after which such retransplantation can be followed by ovulatory function.

(3) To determine whether individual or genetic modifications occur in the progeny from retransplanted ovaries.

(4) To establish the length of splenic sojourn necessary before an irreversible change toward carcinogenic potentiality occurs in the ovary.

At present clear evidence has been obtained bearing on objectives (1) and (2).

Ovulatory function has been resumed by retransplanted ovaries, and viable young have been obtained from ova liberated after 14, 28, 35, 42, and 60 days' sojourn of the ovary in the spleen.

Successful ovulatory function of retransplanted ova appears, however, to decrease progressively as the length of the splenic sojourn increases.

The successful resumption of the ovulatory function and the survival of fertile progeny make it possible to attack the third and fourth objectives.

In addition to providing an opportunity to study the relationship of mutation to carcinogenesis, and the time and nature of the carcinogenic changes in the splenic transplants of the ovary, the existence of at least 9 strain differences in the structure and function of the ovary can be investigated under parallel environmental stress of the splenic environment.

Mechanism of Coagulation of Plasma Albumin by Urea

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Although urea dissolves certain types of protein gels, it induces gels in concentrated solutions of other proteins such as albumin (Ramsden, 1902). The presence of sulfhydryl groups is essential to this urea-induced coagulation of plasma albumin. The addition to urea of small amounts (1 equiv/mole albumin) of all classes of reagents which destroy – SH prevents the formation of these gels of albumin. Also, preliminary treatment of the albumin to eliminate its sulfhydryl group, with subsequent removal of the sulfhydryl reagent, renders the protein incoagulable in urea; the addition of minute amounts of – SH restores the capacity of the protein to gel.

It appears that urea disrupts the structure of certain proteins such as plasma albumin, making disulfide groups reactive to small concentrations of sulfhydryl. By means of a chain reaction between protein-sulfhydryl and protein-disulfide groups a reticulum is knitted together, consisting of intermolecular protein-disulfide bonds which hold together the extended protein chains. The liquid phase is bound to the protein within this framework, and clear firm gels result.

Evidence for the Occurrence of True Mitosis in Bacteria

Edward D. DeLamater, ***University of Pennsylvania***

Previous methods, utilizing the electron microscope, quartz optics and ultraviolet light, and routine light microscopy, have demonstrated the presence of probable nuclear structures in bacteria and the fact that these bodies reduplicate themselves. Intrinsic structure and the mechanisms of division have, however, remained obscure. With the development of new methods which utilize an essentially new approach to the dehydration of tissues and cells, details of nuclear structure and divisional mechanisms have become visualizable. The method takes advantage of the fact that it is possible to remove water from tissues in the frozen state at very low temperatures (–50° C) by the use of chemical dehydrating agents, such as alcohol, acetone, and ethylene glycol, which remain liquid at these low temperatures. No vaporization of the water from the frozen state in a vacuum is necessary. The use of alcohol or acetone adds the further desirable advantage of leaching out fatty substances in the cell which tend to obscure detail. This solvent also hardens the fabric of the cell as dehydration proceeds. Instantaneous freezing prevents initial distortion of the intrinsic structure.

By means of this new procedure clear-cut evidence for the occurrence of a typical mitotic process in several representative forms of bacteria has been demonstrated. Members of the genera *Bacillus, Escherichia, Micrococcus,* and *Caryophanon* have been studied.

The mitotic cycle undergoes recognizable prophase, metaphase, anaphase, and interphase stages. Polar bodies, or centrioles, appear at prophase, separate to the poles at metaphase, and persist into telephase. At interphase the chromosomes elongate into long, delicate, beaded threads.

Observations on Developing Bacteriophage

Ralph W. G. Wyckoff, ***National Institutes of Health***

Electron micrographs of *E. coli* diseased with bacteriophage have shown objects that may be incompletely developed particles of the viral agent. For an understanding of the way bacteriophage grows, it is important to see these objects as clearly as possible in relation to the bacteria in which they form. Comparative preparations using a single broth culture of infected bacteria have therefore been made in ways designed to clarify these relationships. These preparations have been (1) pseudoreplicas of the total content of the culture, (2) deposits of the infected organisms dried from water and from a liquid of low surface tension, and (3) sections through the organisms to reveal their contents. Electron micrographs demonstrate the influence of these methods of treatment on the appearance of the infected cells. They give new information about changes that occur after adsorption of the infecting bacteriophage, they show bacteriophage developing within the bacteria before lysis, and its escape afterwards. They also demonstrate how the observed mechanisms of lysis account for the different phenomena produced by fast and slowly lysing strains. Extension of these observations should add much to our mounting knowledge of the way bacteriophage destroys susceptible bacteria and multiplies at their expense.

The Influence of Intracellular Electrolytes upon Tissue Protein Repletion

Paul R. Cannon, Laurence E. Frazier, and Randolph H. Hughes, ***University of Chicago***

The influence of potassium, phosphorus, and magnesium deficiency upon the processes of growth suggests their

probable importance, also, in relation to tissue protein repletion. This latter problem has been investigated by us in protein-depleted adult rats.

Because during protein depletion much of the lost tissue nitrogen comes from muscle, there is also a concomitant loss of intracellular ions, viz., potassium, phosphate, and magnesium. When protein-depleted animals are fed a repletion ration which supplies all dietary constituents essential for effective tissue protein repletion, except for the absence of one or more of these electrolytes, the processes of tissue repletion are markedly impaired. For example, when potassium is omitted from the diet the animals lose appetite, fail to regain weight rapidly, and develop severe myocardial "necroses" within 6 days. Within 2–3 weeks many of them die of congestive heart failure. The addition of potassium chloride to the diet causes a resumption of the usual course of tissue protein repletion and a resolution of the myocardial lesions. The dietary omission of phosphate leads, also, to a marked interference with tissue repletion; and omission of both potassium and phosphate induces a slower rate of repletion than does omission of either electrolyte alone.

These observations reemphasize the probable importance of intracellular electrolytes in relation to total parenteral alimentation and suggest a need for better balanced electrolytic solutions in order to supply those intracellular ions presumably necessary during the period of reconstruction of intracellular protoplasm.

The Antrum of the Stomach; an Endocrine Organ Concerned with Gastric Secretion

Lester R. Dragstedt, ***University of Chicago***

It is well known that the presence of food in the stomach excites the secretion of gastric juice by the glands in the mucous membrane. This stimulation can occur even after the vagus nerves, which contain secretory fibers to the gastric glands, have been divided. It has been attributed to the formation of a hormone or chemical excitant to gastric secretion in the mucous membrane of the stomach or upper intestine on contact with food. In a further study of this problem in dogs provided with isolated stomach pouches of various types, my associates and I have found that removal of the antrum, or lower portion of the stomach, causes a profound reduction in gastric secretion. Removal of one half, or even two thirds, of the antrum may have no effect, but when the remaining remnant is removed, the full effect is seen. Transplantation of the antrum of the stomach to the abdominal wall so that it does not come in contact with food causes the same decrease in gastric secretion obtained when the antrum is removed. Subsequent transplantation of the antrum into the duodenum as a diverticulum restores the gastric secretion to its normal value. Transplantation of the antrum to the colon as a diverticulum so that it comes in contact with fecal material causes an excessive secretion of gastric juice in the stomach with the regular formation of peptic ulcers. Transplantation of the middle or upper part of the stomach into the duodenum or colon has no stimulating effect on gastric secretion. It is concluded that the mucous membrane of the antrum of the stomach is a specific internal secreting organ concerned with the elaboration of a chemical substance that stimulates the secretion of gastric juice on contact with food. An excessive activity of the antrum is produced when it is transplanted into the colon, and this excessive activity results in the formation of experimental ulcers.

A Factorial Study of the Supreme Court

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The object of the present study is to ascertain by factorial methods whether the voting records of the individual judges give evidence of any groupings in the Supreme Court. This paper is an exploration in scientific method on the problem of identifying the blocs or subgroups within a larger group, as in a legislature, council, or court, in terms of the voting records of the members. The present study was made on the voting records of the Supreme Court judges during the terms 1943–44 and 1944–45 on 115 cases in which there were at least two dissenting votes. A correlation coefficient was computed for each pair of judges. These coefficients indicate the extent of agreement or disagreement among the judges. The coefficients were assembled in a square table of order 9×9, which is called a correlation matrix.

The correlation matrix was factored by the complete centroid method. Three common factors were sufficient to account for the observed correlations. A three-dimensional model can be made to represent the correlations. Each judge is represented by a vector, and each correlation by the scalar product of two vectors.

The multiple-factor methods seem to be promising for analyzing loyalties and identifications by the voting records of the members of a group.

Direct Currents of the Brain

Wolfgang Köhler, ***Swarthmore College***

The recording of direct currents from the heads of human subjects (*Science*, **110**, 414 [1949]) has been continued in collaboration with R. Held and D. O'Connell. It has been confirmed that, when objects move across the visual field, currents spread in the visual cortex, and that the behavior of these currents agrees with known facts of brain localization. More recent records have shown that dark objects which move on a bright ground also establish currents. Currents of stationary objects have been found to be less intense than those of moving objects, presumably because the former cause stronger electrotonic obstruction. Accordingly, the current of a moving object is abruptly weakened when the movement is suddenly interrupted. The investigation of cortical currents can probably not be separated from the study of their electrotonic action.

When the position of the "active" electrode corresponds to the region of the auditory cortex, a steady flow is registered during stimulation of the ear. Experiments in which the active electrode is placed on the exposed auditory cortex of animals have just begun. Results agree with findings obtained from the intact heads of human subjects. The electrotonic obstruction caused by currents in this area seems to be weaker than that caused by visual currents.

Both visual and auditory currents are generally followed by afterpotentials which have the same polarity as the original currents. Under the influence of many exposures these afterpotentials tend to grow, and then to be spontaneously repeated as long sequences of slow waves.

The Mass Spectrometer as a Research Tool

Alfred O. C. Nier, ***University of Minnesota***

During recent years the mass spectrometer has been

developed to be a useful research tool in many fields. The isotopic composition of almost all elements is now well known. Stable isotopes have become valuable as tracers in biological and geochemical investigations. Electron impact studies of molecular gases have led to useful data on molecular structure. As analytical tools, mass spectrometers have proved their worth for making chemical analyses and for hunting leaks in vessels. Continuous recording instruments have been employed in making continuous analyses of gas streams. Use of such instruments has been made in industry and in medicine.

A summary of recent work in mass spectrometry illustrated by examples of current applications is given.

Quantum Dynamics

Julian Schwinger, ***Harvard University***

The conventional quantum mechanics of particles and fields consists of a set of correspondence rules which are superimposed on the classical mechanics of a given dynamical system. It is our purpose to provide a self-contained basis for quantum dynamics by means of a single fundamental principle, from which operator equations of motion and commutation relations can be obtained. The principle is stated as a variational equation for the transformation function connecting eigenvectors of complete sets of physical quantities at different times, for nonrelativistic particle dynamics, and on different spacelike surfaces, for relativistic field dynamics. Generating the infinitesimal change of the transformation function is the variation of an operator which is called the action integral, according to its classical analogue. We deduce an operator principle of stationary action, which yields the equations of motion for specific dynamical systems. The boundary terms in the action principle provide infinitesimal generating operators which imply the commutation relations of the system. An invariant field action integral guarantees that the structure of the dynamical principle is unaltered by relativistic coordinate transformations, with the exception of time reflection, where a separate discussion is required. It is shown that the latter cannot be included within the unitary transformation framework of quantum mechanics, but requires the transposition of all operators for its representation. The requirement of time reflection invariance then restricts the operator properties of a field in a manner which is simply the connection between the spin and statistics of elementary particles.

High Resolution of the Near Infrared Spectra of Simple Polyatomic Molecules

Earle K. Plyler, ***National Bureau of Standards***

With the availability of photoconducting cells it has been possible to increase the resolving power of grating instruments in the near infrared region by a factor of five. By using the highest grade optics for the mirrors and the grating it is possible to use 0.02-mm slits. With such slits lines can be resolved which are separated 0.12 cm^{-1} at 2 μ.

The spectra of many molecules have been measured in the region from 1.2 to 2.8 μ.

The rotational vibration bands have been measured by placing on the recorder trace the emission lines of different gases such as krypton and argon. By having a large number of comparison wavelengths the positions of the rotational lines can be determined to ± 0.03 cm^{-1}. Two bands of C_2D_2 at 1.96 and 2.39 μ have been measured, and the rotational constants determined. It is possible to determine the ground state rotational constant (B_0) to the fourth decimal place by accurate measurement of these two bands.

Sixteen bands of C_2H_4 have been measured from 1.6 to 2.6 μ. The combination bands indicate that one of the stretching vibrations of CH (ω_5) should be assigned a value of 3,075 cm^{-1} instead of the present assignment of 3,273 cm^{-1}. The rotational structure has a coarse spacing of about 8.1 cm^{-1} and fine spacing of 1.8 cm^{-1}. In addition many small lines are observed in the spectra which have not been previously resolved. These extra lines are produced by interaction of the higher states.

Theory of Molecular Complexes

R. S. Mulliken, ***University of Chicago***

Generalization of previous ideas gives a simple quantum-mechanical theory of molecular complexes. Let A be an electron acceptor and B a base (electron donor). Typically, A may be a neutral molecule or a positive atom-ion, B a neutral molecule or negative atom-ion. For example, A may be I_2 or Ag^+, B may be benzene or I^-.

Most often, A and B have even-electron diamagnetic structures. Then A and B, and therefore the complex $A \cdot B$ have totally symmetrical singlet wave functions. These can be written as

$$\psi = a\psi_0 + b\psi_1 + \ldots\ldots\ldots\ldots\ldots . \qquad (1)$$

Here ψ_0 is usually a *no-bond* function $\psi(A, B)$ and ψ_1 a *dative* function $\psi(A^-—B^+)$ with covalent bond between A^- and B^+ (weak in loose complexes, strong in molecules such as $R_3N \cdot BX_3$). Eq. (1) also fits simple molecules like HCl or NaCl taking A as H^+ or Na^+ and B as Cl^-; but now ψ_0 involves ionic bonding, and ψ_1 only covalent bonding (A^- and B^+ are atoms).

Eq. (1) involves resonance energy of approximate amount

$$RE \approx W_{01}^2/(W_1 - W_0). \qquad (3)$$

Here W_0, W_1 are the energies of pure ψ_0, ψ_1; W_{01} is a matrix element.

The *"charge-transfer forces"* corresponding to Eq. (3), although more specific and valencelike, to some extent resemble London's dispersion forces, and apparently must share with the latter in accounting for van der Waals attractions. Charge-transfer forces, however, should have strong orientational properties, of probable importance in determining how molecules pack in crystals or liquids. This is because resonance requires that ψ_1 and ψ_0 have the same group-theoretical symmetry. Thus in $Ag^+ \cdot$ benzene, $\psi_1(Ag—Bz^+)$ violates this requirement if the silver atom is either on the benzene sixfold axis or in the ring plane.[1] An intermediate location is thus indicated. This prediction is supported by experimental evidence.

[1] This is because the Bz^+ wave function has nodal planes through both locations, whereas the Ag function has none.

The Oxidation-Reduction Theory of Latent Image Formation

W. G. Lowe, ***Eastman Kodak Company***

Current theories consider latent image formation in the photographic emulsion to be a reduction process involving

electron capture at trapping sites. Gurney and Mott assume the presence of chemical impurities. Mitchell suggests a physical trap (positive Schottky defect) but requires mobility of the positive defect for latent image formation.

Recent results show that the unsensitized emulsion possesses sensitivity due to the presence of unoxidizable, "primitive" traps, whereas the effects of chemical sensitizing can be quantitatively destroyed by oxidation. Controlled reduction of the emulsion gives reduction sensitizing, which is chemically distinct from any stable stage of latent image formation. The action of certain oxidizers on the reduction-sensitized emulsion gives results (latent image formation, latensification) similar to the action of low-intensity light on the primitive emulsion.

It is suggested that the primitive traps in the silver halide grain are "frozen-in" groups of Schottky defects at free and internal surfaces, stabilized at the free surfaces by adsorbed colloid. In this model latent image formation is an oxidation-reduction reaction in its first stage, involving trapping of electrons and positive holes at the primitive trap. In its second stage it follows the Gurney-Mott mechanism, the latent image acting as a deep chemical trap. In terms of this model it is possible to describe reduction sensitizing, the unstable subimage, the first stable subimage, the latent image, selective desensitizing, latensification by oxidizers, and the mechanism of print-out.

Schizoid Behavior of Liquids

Kenneth C. D. Hickman, ***Eastman Kodak Company***

Experiments are showing that liquids tend to develop a surface film that hinders evaporation. The film is probably due to traces of soluble impurity which become preferentially located in the surface of any undisturbed liquid. The effect is noticeable chiefly under high-vacuum distillation, when the surface may separate abruptly into two areas, a smooth "torpid" section and a violently agitated "active" section. Certain mixed liquids present an entirely torpid surface, some chemically pure liquids an all-active surface, but the usual condition is "schizoid," with both surfaces present and separated by a steep barrier. The active area is depressed below the torpid by a depth equal to the difference of recoil from their projective vapors. Both the accommodation coefficient and relative volatilities (from mixtures) are low for the torpid area, high for the active. The effect is best seen between 10 μ and 10 mm absolute pressure and has been observed on most of the liquids so far examined, for instance on silicones at 220° C, di-octyl phthalate at 150° C, *n*-octamol at 0° C, *n*-butanol at –30° C, ethanol at –45° C, and propane at –150° C. Torpidity appears to be a fundamental condition of surfaces; the experimental examination of the effect is not difficult.

The Mechanism of Optical Sensitization

B. H. Carroll and W. West, ***Eastman Kodak Company***

Optical sensitization of photographic emulsions by adsorbed dyes involves an interaction between dye and silver halide producing latent image through the absorption of less energy than is required by the silver halide alone. The energetics of the process is still problematical, but recent studies have widened our knowledge of sensitization as influenced by the state of the dye. In effect, the optically excited dye transfers energy to the silver salt, generating a quasi-free electron which initiates latent image formation. At low concentrations, individual dye molecules adsorbed at random over the grain surface may be highly efficient in this process. At higher concentrations the adsorbed dye assumes a new cooperative state, characterized by strong lateral interactions between dye molecules, and often by new absorption bands, displaced from the molecular bands. In the cooperative state energy absorbed by any one molecule flows rapidly throughout the whole layer, the short interaction time at any surface site causing inefficiency in sensitization. The efficiency of the cooperative layer can, however, be increased by small additions of foreign substances. These ***supersensitizers*** appear to form perturbed sites in the layer at which energy propagation is retarded, with consequent increase in the probability of transfer to the silver halide. The inverse phenomenon also exists, in which perturbing molecules, *antisensitizers*, by accepting and degrading the excitation energy of the sensitizer, strongly inhibit transfer to the grain. Super- and antisensitizers influence photoconductivity parallel to photographic sensitivity, showing their direct participation in primary sensitization.

The Diffusion Coefficients of Electrolytes in Dilute Aqueous Solutions

Herbert S. Harned, ***Yale University***

By employing electrical conductance as a measure of concentration, a method has been developed for the determination of the differential diffusion coefficients of electrolytes. Measurements at concentrations between 0.0005 and 0.5 *N* show that the accuracy of the evaluation of the diffusion coefficient is of the order of 0.1%. Indeed, with potassium chloride at 0.2–0.5 *N*, values obtained by the conductance method and the recently developed Gouy interference fringe method agree within 0.05%.

The most valuable feature of the method resides in the fact that, for the first time, results of sufficient accuracy are available for testing the accuracy of the limiting equation of Nernst, and the theory of Onsager and Fuoss for the variation of diffusion coefficients of electrolytes with their concentrations in dilute solutions.

The results for 14 electrolytes of various valence types lead to the following conclusions: (1) The Nernst limiting equation is valid. (2) In all cases, the results approach the values predicted by the limiting law of Onsager and Fuoss as the concentrations of the electrolytes approach zero. (3) Remarkable agreement with theory in dilute solutions is observed for a few electrolytes. (4) Departures from the theoretical predictions sometimes occur.

Electromotive Force from Proton Exchange Reactions

Theodore Shedlovsky
Rockefeller Institute for Medical Research

Electrochemical cells derive energy from oxidation-reduction, i.e., electron exchange reactions which occur at the electrodes, anode and cathode, when electron transport is available at these sites through metallic conduction.

Similarly, acid-base—i.e., proton exchange reactions—may be expected to yield electrical energy if proton transport is available at the sites—i.e., "protodes" at which protons are exchanged.

Proton conduction exists in acids and also in water. The familiar glass "electrode" is a hydrogen ion protode at which the reaction H_3O^+ (hydrogen ion) $= H_2O + H^+$ (proton) takes place.

An insoluble acid H^+A^- and its insoluble salt, M^+A^-, may be expected to behave as an M^+ ion protode through the reaction $M^+A^- + H^+$ (proton) $= H^+A^- + M^+$ just as the silver–silver chloride electrode behaves as a Cl^- ion electrode through the reaction $Ag + Cl^- + \varepsilon^-$ (electron) $= Ag^+\varepsilon^-$ (silver) $+ Cl^-$, with the difference that a proton is involved in one case and an electron in the other.

To test these ideas, a study was made of cells containing a glass (hydrogen ion) protode and a lauric acid–barium laurate (barium ion) protode in buffered barium chloride solutions of various compositions. The potentials of these cells varied linearly with the logarithm of the activity of the barium ion constituent and with the pH in accordance with theory.

Since metallic conductors are not present in living cells, oxidation-reduction reactions cannot be the immediate energy precursors for bioelectric phenomena; proton exchange reactions may, however, play an important part.

Configurational Standards and Configurational Relationships in Organic Compounds

M. L. Wolfrom, *Ohio State University*

Considerable confusion exists among chemists regarding configurational standards and configurational relationships. A group of substances containing asymmetric centers can be related to each other through the selection of a suitable reference standard. Such a standard must contain only one asymmetric center whose orientation is assumed. To arrive at a rational system of relationships it is then necessary to establish a series of groups arranged in an order which will give precedence to the groups to be selected for the top and bottom of the tetrahedral orientation. When more than one asymmetric center is present in a compound, each center may be considered to be related to the reference standard to give a composite picture. It is convenient, however, to select one center as a reference for the entire compound or series of centers. This is best done by selecting the center at one or the other end of the sequence. This involves again an orientation as to which end shall take precedence. The same reference series could likewise be used to decide this issue.

Separation and Characterization of High Molecular Weight Polypeptides

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Rockefeller Institute for Medical Research

Attempts to develop adequate methods for the separation and characterization of polypeptides have led to the construction of automatic discontinuous countercurrent extraction equipment containing 220 equilibrium cells in a single train. This, together with the discovery of suitable liquid-liquid systems, permits clear-cut separation of the naturally occurring peptides.

In this work it has been noted that any change involving an acidic or basic group has a striking effect on the partition ratio of the peptide in a given system. An approach to the problem of molecular weight determination is thereby suggested.

Analysis for a given substituent permits calculation of a molecular weight if the number of such substituents can be determined. A countercurrent distribution pattern obtained after partially transforming the peptide with a suitable reagent (fluorodinitrobenzene, esterification, etc.) permits the number of such groups to be derived.

In the case where the DNP reagent is used, the appearance of two well-separated bands, one the unreacted peptide and the other a yellow band of the derivative, will indicate the presence of a single amino group in the molecule. The appearance of a second yellow band indicates two amino groups, etc.

On the Existence of a Basis for Every Finite Abelian Group

Jesse Douglas, *Brooklyn, New York*

Every element Θ of a finite commutative group G can be expressed uniquely as a product of powers of a chosen set of elements $a, b, \ldots, c$ of G: $\Theta = a^\alpha b^\beta \ldots c^\gamma$. The proofs of the existence of this *basis* for G given in the standard treatises are usually fairly complicated, involving an inductive procedure. The present paper gives a simple constructive type of proof patterned after the elementary one for a basis of a vector space—the fundamental idea of which is the striking out of vectors that are linear combinations of other vectors yet remaining unstricken.

This idea, however, does *not* permit of *immediate* transfer to Abelian groups—if we remove systematically elements that are power products of other elements yet remaining, we shall generally *not* be left with a basis.

Supposing G to be of prime-power order, the point is first to *arrange* the elements of G in *nonascending* order of their *periods*, then moving through the elements of G in this order, to strike out each element expressible as a power product of elements as yet unstricken. The elements remaining at the end of the process are a basis.

If the order of G is $g = p^h q^k \ldots r^l$, where $p,q, \ldots, r$ are different primes, then G is the direct product of Abelian groups of the respective orders $p^h, q^k, \ldots, r^l$, so that the general case is reduced to that of prime-power order.

Capella, the Anchor of Eddington's Mass-Luminosity Relation

Otto Struve, *University of California, Berkeley*

Capella, or Alpha Aurigae, is the second brightest star in the northern sky. A giant pair of suns, of approximately the solar temperature but almost ten times larger than the sun in size, revolve around one another in a period of 104 days. At Mount Wilson, Anderson and Merrill have resolved the pair with a large interferometer. This circumstance makes it possible to determine the masses of the component stars designated by the letters G and F. About 30 years ago A. S. Eddington recognized that the masses of these solar type stars are about four times greater than the mass of the sun, and their luminosities about 100 times greater. This led him to suspect that the energy production in a star depends almost entirely upon its mass: the cosmic nuclear energy machine works more efficiently for large masses than for small! (In fact, Eddington attached his famous mass-luminosity relation to the observed parameters of Capella at one end and the sun at the other. In one way or another this unusual

significance of Capella has influenced all more recent astrophysical discussions of the production of energy in stellar interiors.)

Recent observations of the spectrum of Capella with high dispersion, at Mount Wilson, show that the F star is peculiar. Ordinarily, the observed absorption spectrum consists of a jumble of thousands of lines, some belonging to the G star, others to the F star. It is like a coded message requiring a key for its decoding. In our case there are two such keys—a normal G-type spectrum (sun or Arcturus) and a normal F-type spectrum (Procyon or Alpha Persei). The former immediately disentangles the G-type lines—there is nothing strange about it. But the latter fails completely. The F spectrum of Capella is unlike that of any other star that I have encountered. Its strong lines are enormously enhanced and broadened, and its weaker lines are completely blocked out. The former measurements of the velocity of the F star are therefore little more than guesses, and hence the resulting masses of both components are uncertain. We have here a fascinating puzzle: first, we must explain the peculiar aspect of the F spectrum; second, we must measure its velocity and thus provide a reliable anchor for the mass-luminosity relation; and, third, we must recognize the growing amount of evidence that *close* binaries are not like single stars. The components disturb one another, and render them "peculiar." Since we use the law of gravity to determine the masses of the stars, and binaries are the only astronomical objects that furnish us with a measure of their gravitational accelerations, it will be advisable to use wide, visual pairs, whenever possible, to study problems of energy generation.

Evolution of the Protoplanets

Gerard P. Kuiper, ***Yerkes Observatory***

The protoplanets developed from the solar nebula as extensive flat gaseous disks rotating in the tidal field of the sun. It is shown that such masses will contract. This increases the angular velocity of rotation until the outer fringes move in nearly free circular orbits. The conditions of ejection from the periphery are developed. It is found that turbulence may attain a velocity dispersion around the circular motion of rotation large enough to cause ejection of part of the gaseous matter. This would lead to a nearly constant total energy content throughout the history of the protoplanets, but a steadily diminishing angular momentum per unit mass.

A more detailed examination of the stability conditions of disklike protoplanets has led to a roughly fivefold increase of the masses found in the first approximation. With these improved masses, the initial (negative) energy content of the protoplanets is computed and compared to the present energy contents. The accord is fair for the Jovian planets, showing here that the hypothesis of ejection produced by internal turbulence alone is fairly adequate. However, for the terrestrial planets, the present energy content is larger, algebraically, than the initial one, proving that the sun supplied energy during the ejection process (as in fact, the sun still does today in the atmospheric ejection of H_2 and He).

The history of the angular momentum content of the protoplanets is nearly, but not entirely, accounted for by the same process of equatorial instability and superimposed solar tidal friction.

There are two stages in the ejection process: Stage A in which the density of interplanetary matter was above 10^{-17} and true evaporation was impossible; the ejection was by eddy escape (hydrodynamic flow), and no fractionation by molecular weight took place. This stage was followed by Stage B, during which true evaporation occurred; it did not begin until Stage A had run its course and the density of interplanetary matter, by turbulent dissipation, had fallen below 10^{-17}. Condensation and sedimentation in this evolution are discussed.

Multiply-recurrent Geomagnetic Activity

Oliver R. Wulf and Seth B. Nicholson
U. S. Weather Bureau at the California Institute of Technology and Mount Wilson and Palomar Observatories

There is a well-known tendency for geomagnetic disturbance to recur after an interval of about 27 days. In certain instances, where such geomagnetic activity was multiply recurrent, an area of bright chromospheric clouds was observed to come around the east limb of the sun, because of solar rotation, at about the time of onset of disturbance. If such areas emit more ultraviolet radiation than an equal area of the undisturbed sun, it appears possible that they may be instrumental in causing irregular air motions in the ionosphere producing geomagnetic disturbance by dynamo action. An extension of this picture suggests a plausible description of the tendency for magnetic bay disturbances to recur at intervals of approximately 24 hr.

Origin of Lake Ilopango, El Salvador

Howel Williams, ***University of California***

An east-west structural trough cuts athwart El Salvador and continues through the Gulf of Fonseca and Lakes Managua and Nicaragua to the border of Costa Rica. In El Salvador, this trough represents the downfaulted crest of a geanticline formed in Late Pliocene or Early Pleistocene time. It was then that the original basin of Ilopango was formed.

Subsequently, a chain of imposing Pleistocene and Recent volcanoes was built within and close to the margins of the trough. Filling of the original Ilopango basin began by protrusion of dacite domes through its sides and by accumulation of fluviatile pumice deposits produced by reworking of ejecta discharged partly from the domes just mentioned and partly from the volcano of San Salvador to the west. Later, colossal glowing avalanches of dacite pumice issued from vents near the center of the basin, almost filling the depression. So copious and rapid was this discharge that support was withdrawn from beneath the vents and wholesale engulfment ensued. The present Lake Ilopango lies within the resultant *caldera.* Collapse took place in post-Pleistocene time. Finally, a new volcano rose from the floor of the lake in 1880: this is a dome of dacite of Peléan type.

Basic Assumption Underlying Paleoecology

W. P. Woodring, ***U. S. Geological Survey***

Reconstruction of the environment of animals that lived during past geologic time is perforce based on the assumption that the animals indicate essentially the same environment as modern animals to which they are closely allied. This assumption has at times been abused by violation of the "closely allied" clause. When properly used, it is justifiable, but, like other generalizations, is

of doubtful validity for some samples. An example of doubtful validity is afforded by the late Pliocene and Pleistocene marine mollusks of California, including even fossils that are indistinguishable from modern species—or are closely allied to modern species—on the basis of morphological characters available to paleontologists.

Modern species that are found as fossils beyond their present geographic range are generally held to be indicators of a corresponding shift of the environment, due to climatic or other change. In the absence of conflicting evidence that inference is plausible. The late Pliocene and Pleistocene marine molluscan faunas of California, however, present conflicting evidence as indicators of past temperature. Species that are north of their present geographic range are found in direct association with species that are south of their present range.

This conflicting evidence might be resolved by postulating subsequent evolution in physiological characters that shows no correlation with evolution in morphological characters available to paleontologists, or by postulating the rise and extinction of local subspecies—or species—differentiated by physiological characters unknown and unknowable to paleontologists.

It is suggested that determinations of temperature coefficient, based on the ratio of the isotopes O^{18} to O^{16} in the calcium carbonate of the fossils, should show whether the conflicting evidence is as irreconcilable as it now appears to be.

The Limiting Negative Pressure of Five Organic Liquids and the 2-Phase System, Water–Ice

Lyman J. Briggs, *National Bureau of Standards*

The limiting negative pressure of the following liquids has now been investigated by a centrifugal method, through the temperature ranges indicated: acetic acid, 16° to 52° C; aniline, – 6° to 53° C; benzene, 6° to 32° C; carbon tetrachloride, –16° to 35° C; chloroform, –15° to 27° C.

The first three liquids all show a maximum in the limiting negative pressure within the temperature range specified, the measurements in each case extending to near the freezing point. In this respect they act similarly to water. The freezing points of the other liquids were beyond the range of the apparatus.

The limiting negative pressure of each of the liquids measured, except benzene, is comparable with, or greater than, that of water, 275 bars. Benzene, a nonpolar liquid, has a maximum value only about one half that of its strongly polarized ($\mu = 1.48 \times 10^{-18}$) derivative, aniline. Chloroform ($\mu = 1.02 \times 10^{-18}$) is greater than nonpolar carbon tetrachloride, but the difference is much less marked. The method employed thus appears to provide a way of measuring directly the contribution of the dipole to the cohesive forces in a liquid by comparing the limiting negative pressure of the *cis* and *trans* forms.

The limiting negative pressure at the interface between ice and water has been measured by freezing the central section of the spinning liquid column, the temperature of the rest of the system being held a little above the melting point. The instant of rupture was detected by the escaping water breaking down the insulation of a filter-paper condenser surrounding the spinner. The limiting negative pressure observed was 8–10 bars, which is consistent with measurements reported last April on water near its freezing point. The negative pressure of ice at 0° C is then equal to or greater than 8 bars.

Radioactivities of the Ordinary Elements; New Data and Systematics

W. F. Libby, *University of Chicago*

Measurements in the past few years have revealed the existence of two new naturally radioactive elements, rhenium and indium, and have set new and stringent limits on the possible radioactivities of other elements. These new data are presented in a summary form. In addition, more accurate measurements on the decay characteristics of several of the naturally occurring active isotopes have been reported. These data seem to suggest certain regularities that may have general interest.

Television as an Educational and Scientific Tool

V. K. Zworykin and L. E. Flory
Radio Corporation of America

Television as an entertainment medium is far advanced and as such is rapidly taking its place with the radio and the movies. Looked upon in its broadest sense, however, television has potentialities extending far beyond those in the entertainment field. In the ultimate, television can be said to be an extension of human vision—not only in distance, but also an extension of color sensitivity into regions of illumination invisible to the eye.

As such an adjunct to vision, television has tremendous possibilities in science and education. Special television equipment, compact, simple to operate and reliable, has been developed for these uses. One of the most promising scientific applications of television is its use in connection with the light microscope. In this application the eye is replaced directly by the television camera, and the image of the microscopic specimen is seen on the television monitor, which may be of any size from the smallest television tube up to full theater screen size for large groups. This method, aside from the added convenience of viewing and its possibilities in classroom instruction, provides an enhancement of contrast that permits the observation of living cells under conditions of contrast previously obtained only by killing and staining. In addition illumination of any wavelength from the red or infrared down to 2,500A or lower may be used, permitting direct observation of structures of tissues and other materials previously possible only by photography. Living organisms may be viewed by certain wavelengths of the ultraviolet, limited only by the killing power of the illumination.

Televised Microscopy in Biological Research

A. K. Parpart, *Princeton University*

The importance of televised microscopy for research in biology arises from the very significant increase in contrast, the wavelength selectivity not only in the visible but in the ultraviolet, and in the ease of following motion within and of a cell at high magnification (×4,000).

A striking example of these three features has been obtained in the erythrocytes of elasmobranchs. Small granules (0.2–0.4 μ) in the cytoplasm have been observed in Brownian and translatory motion within these cells. This has made it possible to establish that there can be no fine meshwork reticular structure within the cytoplasm of these cells. It can therefore be said that the normal shape and the changes in shape resulting in hemolysis are

the resultant of surface changes in these cells rather than due to an organized internal structure.

Experiments with Π^--mesons from the Nevis Cyclotron

E. T. Booth, *Columbia University*

Negative π-mesons of 75 mev kinetic energy are produced in the Columbia cyclotron by allowing 385 mev protons to strike a beryllium target inside the accelerating chamber. Mesons projected in the forward direction from the target are deflected by the magnetic field of the cyclotron and are allowed to pass through an opening in the concrete shield surrounding the machine. In this way a particle flux of 10 mesons/cm²/sec is obtained in a shielded experimental area.

Experiments conducted both with a cloud chamber and with photographic plates in this meson beam are discussed. Cloud chamber results are presented of the interactions of these mesons with a carbon plate placed in the chamber. Nuclear plate studies of the interactions of the mesons with emulsion are also reported.

Investigations with the MIT Synchrotron

B. T. Feld, *Massachusetts Institute of Technology*

The MIT electron synchrotron is operating at energies up to 340 mev. Electrons fall on a thin tungsten target, producing a beam of x-rays which is collimated and then allowed to fall on a target. Current and contemplated experiments discussed include the following:

1. Mean life and decay scheme of positive π-mesons.
2. Spectrum and angular distribution of charged π-mesons produced in H, D, and C; mesons detected in photographic emulsions; H and D results obtained by difference between paraffin and carbon.
3. Cross section for charged meson production by various elements; mesons detected by liquid scintillation counters.
4. Production of neutral π-mesons in hydrogen gas, by detection of the proton recoils in photographic emulsions.
5. Scattering of γ-rays by protons in the energy region of the meson production threshold; detection same as for (4).
6. Direct observation of meson production in electron-sensitive nuclear emulsions.
7. A search for the creation of μ-meson pairs, using liquid scintillation counter detectors.
8. Spectrum of electrons from μ-decay, observed in a cloud chamber.
9. Study of absorption of negative π-mesons in pure materials; high-pressure and ordinary cloud chambers.

Recent Work on Mesons at the University of California Radiation Laboratory

C. Richman, *University of California*

The study of mesons with the use of the Berkeley synchrotron and synchrocyclotron has been, first, a study of the production of mesons. It has been found that π^{+-}, π^- and π^0-mesons are produced by the bombardment of nuclei by γ-rays as well as by nucleons. The detection of the π^0-meson by the coincidence of 2 γ-rays into which it decays shows that it is not a particle of spin $\frac{1}{2}\hbar$ or $\hbar$. Its spin is therefore probably 0. For comparison with the theory the production of mesons from hydrogen is particularly interesting. A study has been made of the reaction $\gamma + P \rightarrow N + \pi^+$. In the proton-proton collision two reactions have been found $P + P \rightarrow N + P + \pi^+$ and $P + P \rightarrow D + \pi^+$.

The capture of π^--mesons by nuclei has been studied. In hydrogen two reactions take place, $\pi^- + P \rightarrow N + \gamma$ and $\pi^- + P \rightarrow N + \pi^0$. In deuterium the reactions are $\pi^- + D \rightarrow N + N$ and $\pi^- + D \rightarrow N + N + \gamma$.

Current Research with Mesons from the Rochester Cyclotron

A. Roberts, *University of Rochester*

The 130-in Rochester cyclotron operates at present with a beam of about 0.1 μa of 240 mev protons. A suitable target produces a flux of π^{+-} and π^--mesons, which are deflected by the fringing field to approximate foci outside the cyclotron tank, but close to it. By taking special precautions, the meson beam can be selectively detected by a scintillation counter telescope. Present maximum flux values are about 250 π^+-mesons/min/cm² at 40 ($\pm$1) mev, and about a tenth as many π^--mesons. Detection by photographic plates or cloud chambers is handicapped by high background intensities.

Current research with mesons is concerned with measurement of the relative yields of π^{+-} and π^--mesons, the Z dependence of meson production, preliminary work directed toward measurement of meson scattering, and an attempt to measure the cross section for the process $\pi^+ + d \rightarrow 2p$. Since the cross section for the inverse of this process has been measured at Berkeley, the measurement should give, by detailed balancing considerations, the spin of the π^{+-}-meson.

High-Energy γ-Ray Studies at Cornell

Robert R. Wilson, *Cornell University*

The Cornell synchrotron gives 310 mev electrons in pulses at 30 cps. The γ-ray intensity produced by these electrons is about 10^5 r/hr behind $\frac{1}{8}$ = Pb at 1 meter. The spectrum has been carefully studied using a pair spectrometer, and is observed to follow closely the Bethe-Heitler theory.

Mesons produced by these γ-rays have been studied in a variety of ways. The neutral meson production in protons has been looked at by observing the recoil of the proton. Silverman and Stearns find the cross section at 300 mev at 90° to be about 10 μb/steradian/γ.

A nearly pure beam of charged mesons is separated by a two-magnet focusing system. The scattering and absorption of these mesons have been studied, using a cloud chamber containing thin plates through which the mesons pass. In light elements such as Al and C, nearly elastic large-angle scattering is observed, as well as star production. It is possible to separate the elastic shadow scattering, which is particularly sensitive to the transparency of the nucleus. Preliminary results indicate that the carbon nucleus is slightly transparent to incident mesons.

The production of charged mesons has also been studied in a number of materials. At 135° from the direction of the incident γ-ray beam and at an energy of about 50 mev, the π^-/π^+ ratio for carbon is 1.04 $\pm$.05; for Be, 2.2 $\pm$.1; for D, 1.4 $\pm$.2; for S, 0.78 $\pm$.05. The ratio of π^+ per proton to π^+ per deuteron is 1.20 $\pm$.16.