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Some Effects of Substituting the Deoxyribonucleic Acid of Isolated Nuclei with Other Polyelectrolytes

The addition of large, negatively charged molecules to isolated cell nuclei which have been depleted of their deoxyribonucleic acid (DNA) restores much of the biochemical activity of the nucleus.

Up to 75 percent of the deoxyribonucleic acid of isolated thymocyte nuclei can be removed by incubation with pancreatic deoxyribonuclease (DNAase). Nuclei so depleted of their DNA lose their capacity for adenosine triphosphate (ATP) synthesis, for amino acid incorporation into protein, and for adenosine uptake in nuclear ribonucleic acids.

If polyanions are added at the time the DNA is removed, one can substitute for more than two-thirds of the DNA without any apparent loss of activity. The polyanions tested include other DNA's, ribonucleic acids, and polyadenylic acid, and *non-nucleotides* such as polyethylene sulfonate, heparin, and chondroitin sulfate. Added polycations, such as protamine or polylysine, do not restore function to DNAase-treated nuclei. Moreover, polylysine, when added to nuclei whose DNA is still intact, greatly inhibits amino acid uptake into nuclear protein.

The findings suggest a correlation between negative charge and the biochemical activity of the nucleus.

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New Coenzyme Containing Pseudovitamin B_{12}

Cell-free extracts of *Clostridium tetanomorphum* decompose L-glutamate by the following sequence of reversible reactions:

$$\text{Glutamate} \overset{\text{I}}{\rightleftarrows} \beta\text{-methylaspartate} \overset{\text{II}}{\rightleftarrows} \text{mesaconate} \overset{\text{III}}{\rightleftarrows} \text{citramalate} \overset{\text{IV}}{\rightleftarrows} \text{pyruvate} + \text{acetate}$$

The rate of reaction I in the forward direction can be measured by coupling it with reaction II and measuring the rate of mesaconate formation spectrophotometrically. Reaction I, which involves the interconversion of straight- and branched-chain C_5 structures, has been shown to require a coenzyme that can be removed from the cell-free extract by adsorption on charcoal. The coenzyme has been purified by ion-exchange methods and found to be a yellow-orange compound with high activity in the enzymatic assay system. The coenzyme is rapidly inactivated by visible light, which also causes a striking change in its absorption spectrum. The light-inactivated coenzyme is red and possesses an absorption spectrum similar to that of vitamin B_{12}. In the presence of KCN the spectrum of the coenzyme is virtually identical with that of vitamin B_{12} except in the far ultraviolet. The coenzyme contains cobalt, cyanide, ribose, phosphate, and adenine, known components of pseudovitamin B_{12}. It also contains one or more additional adenine-containing moieties which are readily split off by exposure to light and appear to be essential for coenzyme activity.

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Effect of Deuterium Oxide on Biological Systems

The price of deuterium oxide (heavy water) has fallen to a fraction of its former value, making possible more extensive investigation into the biological effects of this substance than had been possible after it first became available 20 years ago.

Different isotopes of an element do not possess identical chemical and biochemical properties, and these differences can be expected to be very large between hydrogen and deuterium because of their large mass difference. Important effects on the structure of biologically significant macromolecules are to be expected. The effects of a deuterium environment on the growth, reproduction, and metabolism of algae, tumor cells, *Drosophila,* and mice have been studied.

Environmental D_2O concentrations in excess of 30 to 40 percent appear to be toxic or to inhibit the growth of the alga *Chlorella,* mice, and *Drosophila.* By serial subculture, algae can be adapted to grow well in D_2O concentrations up to about 60 percent. Unadapted cells form giant cells at high D_2O concentrations due to a failure to divide.

Mice (strain C_{57}) maintained on 25 and 30 percent D_2O in their drinking water and inoculated with Ehrlich's ascites tumor cells showed an increase in survival time of about 50 percent compared with control mice inoculated but maintained on ordinary water.

Heavy water decreases the fertility of mice. The effect is more pronounced in male mice, and recent studies have shown that the development of the spermatozoa is impaired. When the mice have been maintained on 30 percent D_2O for 4 or more weeks, many sperm appear by microscopic examination to be morphologically defective.

The development of *Drosophila* is inhibited by D_2O in the media. Experiments are in progress to investigate possible mutagenic effects of D_2O.

This work was sponsored by the U.S. Atomic Energy Commission.

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Thermodynamic Properties of a Biological Steady-State System as Represented by the Carbon Reduction Cycle in Photosynthesis

The biochemical pathway of carbon reduction during photosynthesis in green unicellular algae has been traced by allowing these organisms to photosynthesize in the presence of $C^{14}O_2$ and subsequently analyzing the C^{14}-labeled compounds thus formed. This metabolic pathway, in part cyclic, lends itself particularly well to studies of the thermodynamic properties of the biological steady-state as an interesting case of the chemical steady-state. The suitability of this system to such studies stems from several factors.

1) The metabolic pathway is to a considerable extent isolated from other metabolic pathways of the cell by the chloroplast membrane and by the fact that the net rates of conversion of the carbon reduction cycle are much greater than the rates of other interacting pathways.

2) The primary reactants (water, carbon dioxide, and light) can be easily maintained at constant levels, regardless of the rate or duration of reaction, and two of these (light and carbon dioxide) can be varied easily to control the rate of reaction.

3) The rate of the reaction can be readily observed without interfering with the system.

4) The concentrations of the intermediates may be determined by means of C^{14} labeling.

The concentrations of intermediates at measured rates of photosynthesis have been determined and used to test the validity of some equations of the thermodynamic steady-state at certain points in the carbon reduction cycle.

This work was sponsored by the U.S. Atomic Energy Commission.

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Effect of Light on the Bioelectric Potential of Nitella

Illumination of one end of *Nitella clavata* cells at first produces no change of potential, but if illumination is continued for about an hour, the light end becomes more and more negative, eventually reaching a value of 50 to 60 mv negative to the darkened end. There is quick recovery on darkening, sometimes with an overshoot to above normal, and the effect can now be repeated almost indefinitely on successive light exposures. The change actually consists of a decreased positive potential at the illuminated end (as is shown by killing the other end, or by inserting a microcapillary contact into the sap). It appears to be photosynthetically mediated, for red light is as effective as blue. It is not, however, enhanced by increased CO_2 content of the water, hence is probably not due to accumulation of photosynthetic products. Indeed, 2 percent CO_2 rather effectively abolishes the light effect.

The light effect is greatest when distilled water bathes the cells and is decreased by added salts, especially by KCl. Even one or two stimulations of the cell also decreases the light effect, probably because of the exit of KCl from the sap. It is suggested that the light effects are due to movements of potassium within the cell, either from cytoplasm to vacuole or vice versa, depending upon the postulated site of the membrane potential (at tonoplast or plasma membrane). This is in agreement with results obtained in other organisms which show increased potassium uptake in the light.

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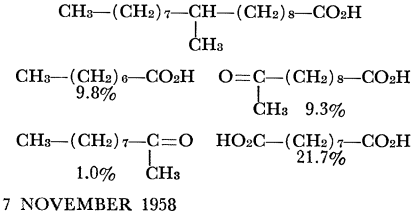
Location of a Branch in a Saturated Carbon Chain

In degradation of natural products, location of a branch in a saturated carbon chain has been traditionally troublesome because of lack of sufficient selectivity in attack at the tertiary carbon. The advent of gas-phase chromatography has rendered possible the detection of such small amounts of material that identification of low yields of degradation products arising from attack at the tertiary carbon becomes feasible if a reaction can be used which gives these products in larger yields than products arising from other positions along the chain. Oxidation with chromic acid in acetic acid solution has been found to be quite satisfactory for this purpose.

A representative degradation is that of 10-methyloctadecanoic acid, which has yielded the indicated products (yields in percentage by weight).



Either the products on the left *or those* on the right fully establish the structure of the acid. Since quantities of 0.01 mg may be readily detected by gas chromatography, the degradation may be applied reliably to samples as small as 5 mg, even in instances where the oxidation is only one-fifth as satisfactory as that cited. In the several branched acids examined, the ketone has usually been the degradation product recovered in lowest yields, which have been in the range of 0.2 to 3.2 percent. The method has failed entirely only for a 4-methyl acid, in which there appears to be no significant selectivity of oxidation at the tertiary carbon. The largest amount of secondary degradation product which has been encountered was no more than 20 percent of the amount of primary product.

JAMES CASON
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Satellite Orbits

Let (r, θ, ϕ) be spherical coordinates describing the position of a satellite relative to the earth: r is radial distance from the center of the earth to the center of the satellite, θ is colatitude, and ϕ is longitude. Assume that the only forces on the satellite are those due to the earth's gravitational potential V. Assume V to be of the form $V = V^0 + JV^2$, where J is the oblateness parameter and V^0 is the potential for a spherical (uniform density) earth [see Blitzer, Weisfeld, Wheelon, "Perturbations of a satellite's orbit due to the earth's oblateness," *J. Appl. Phys.* **27**, 1141 (1956)]. For an initial position x^0 and initial velocity v^0 let $r = r(t, x^0, v^0, J)$ be the radial distance of the satellite. Let $R(x^0, v^0, J)$ = maximum over all t of $r(t, x^0, v^0, J)$. For orbits which do not pass over the poles or lie in the equatorial plane it is shown that $R(x^0, v^0, J)$ is a discontinuous function of J. The discontinuity occurs at $J = 0$, it is a simple jump, and the size of the jump is given. If one describes the motion as that of a point on a moving ellipse, the standard expressions for the rotation of this plane (at nearly constant inclination about the north-south pole axis) and the rotation of the ellipse in this plane are derived. The jump enters in that the eccentricity of this ellipse undergoes a slow periodic variation of period proportional to $(1/J)$, but the amplitude depends only on initial conditions.

STEPHEN P. DILIBERTO
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Climatic Significance of Marine Invertebrates during Later Geologic Time

The broad distribution of modern shallow-water marine invertebrate faunas is controlled to a major degree by temperature. Fossil faunas are considered to have been similarly controlled. The distribution and relationships of fossil marine faunas when compared with those of living faunas indicate that the continents and geographic poles were in their present positions during the Tertiary and strongly militates against changed positions during the Paleozoic and Mesozoic. Fossils closely related to organisms now living occur in the late Mesozoic and Tertiary and form the basis for direct inferences about the distribution of temperature zones during these intervals.

The low- and middle-latitude occurrences of warm-water marine faunas during the late Mesozoic and early Tertiary indicate that the tropics (in terms of temperature) then extended above the middle latitudes. Subsequently the tropics were restricted toward the equator until the time of maximum glaciation during the Pleistocene, with later expansion to their present area. The early Mesozoic and Paleozoic marine faunas have distribution patterns similar to those of the Tertiary and Recent, indicating the presence of comparable temperature zones. Analysis of the faunas indicates that during most of this time the tropics were as widespread as those of the early Tertiary, although there was at least one major glaciation (late Paleozoic).

In summary, during the Paleozoic, Mesozoic and Tertiary, it appears that the tropical zone was usually much more widespread than now, and that restricted tropics, including those of the present time, are abnormal.

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Size of Pores and Their Contents in Sieve Elements of Dicotyledons

Comparative structure and cytophysiology of sieve elements suggest that the strands connecting the protoplasts of contiguous elements through pores in sieve areas play an important role in translocation of food in the phloem. The pores and their contents—that is, the connecting strands and the callose cylinders encasing the strands—were measured in 150 species of some 60 families of dicotyledons. The diameters of the pores ranged in different species from a fraction of a micron to about 14 μ. Typically, in the same species, the pores were larger in the sieve areas of the sieve plates (end walls bearing comparatively highly differentiated sieve areas) than in those in the side walls. The pores and the connecting strands of the sieve plates were larger, and the differences in dimensions between the pores and the strands of the sieve plates and those in the side walls were greater, in elements with simple sieve plates than in those with compound sieve plates. Whether the sieve plates are simple or compound, sample measurements indicate a wide variation in ratio between total pore area per sieve plate and transverse area of sieve element; this ratio tends to be greater in elements with compound sieve plates.

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Enzymatic Conversion of Uridine Diphosphate D-Glucuronic Acid to Uridine Diphosphate Galacturonic Acid, Uridine Diphosphate Pentose, and Xylose Polysaccharide

Sugar nucleotides have been shown to be important precursors in the formation of the various complex saccharides in animal, microbial, and plant cells.

The results obtained by several investigators working with intact plants and plant tissue slices indicated that the D-xylose and L-arabinose constituent units of pentosans originate from uronic acid precursors by a loss of the sixth carbon atom. However, the mechanism of formation of these compounds has not been known.

We now have evidence that particulate preparations from *Phaseolus aureus* (mung bean) seedlings are capable of catalyzing the formation of uridine diphosphate galacturonic acid and uridine diphosphate pentose from uridine diphosphate D-glucuronic acid. It thus appears that the mung bean particulate preparations contain a 4-epimerase capable of converting uridine diphosphate D-glucuronic acid to uridine diphosphate galacturonic acid, and another enzyme (or enzymes), decarboxylase, which decarboxylates the uridine diphosphate uronic acid (or acids) to uridine diphosphate pentose (or pentoses).

Particulate preparations from asparagus shoots, radish roots and leaves, and spinach leaves are also found to catalyze these reactions.

There is evidence that preparations from asparagus and other plants contain an enzyme system that can catalyze the transfer of xylose from uridine diphosphate xylose to β-1,4-linked xylo-oligosaccharides, ranging in degree of polymerization from 2 to 5, to produce the next higher member of the same xylo-oligosaccharide series. There is an indication that a polysaccharide, xylan, is also formed from UDP xylose by preparations from the same plants.

D. S. FEINGOLD, E. F. NEUFELD, W. Z. HASSID
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Low-Frequency Propagation in the Ionosphere

The electromagnetic field produced by a low-frequency vertical electric dipole is expressed as a sum of modes traveling in the "leaky" waveguide formed by the perfectly conducting earth and the imperfectly conducting ionosphere. An analysis of the field shows that the long-distance propagation of radio waves depends on either the first or the zeroth order mode, depending on whether the ratio of the height of the ionosphere to the free-space wavelength is greater or less than $3^{-\frac{1}{2}}$. The problem of numbering the modes is considered, and it is found that in all proposed schemes there is a possibility of ambiguity in numbering.

BERNARD FRIEDMAN
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Lower Jurassic (Toarcian) Flora from the West Coast of Vancouver Island

Plant-bearing strata have been discovered in a small sea-coast section consisting of calcareous shale, siltstone, sandstone, and tuff on the remote western coast of Vancouver Island. The plant-bearing section is underlain and overlain by beds containing marine faunas. The association of the flora with faunas substantiates the age determination based on an independent study of the plants. Petrifactions of the rachises of several genera, preserved as compressions, are of interest because of the rareness of such fossilization combinations. The flora is predominantly cycadeoid. *Ptilophyllum, Pterophyllum, Otozamites, Matonidium, Dictyophyllum,* and *Nilssonia* are the dominant elements. Conifers are rare. The various species of these genera appear to have remarkably close affinities with those of the early Jurassic floras of Mexico, Alaska, Japan, Korea, and elsewhere where floras of this age are recognized. The discovery of this locality eliminates a geographic gap between the flora in northern North America and Asia and those of the Pacific region and Mexico. There is every likelihood that extensive floras of a reasonably uniform composition existed on the fringes of the northern and western Pacific land areas during early Jurassic time.

WAYNE L. FRY
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Development of a High-Field Magnet

The design and arrangements for the safe operation of a kerosene-cooled, iron-free, solenoid magnet for continuous operation at fields in the 100,000-gauss range will be described.

The objective has been to have a relatively large working space, with the best attainable homogeneity, and maintenance of the current distribution patterns at all fields during a series of experimental observations over the range zero to maximum field. The construction details will be illustrated by slides and a visit to the Low Temperature Laboratory of the University of California, where the magnet was developed, is scheduled.

The Office of Naval Research, the Atomic Energy Commission and the National Science Foundation have contributed to the magnet development.

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Scattering of High-Energy Electrons by Deuterons

The bombardment of deuterium by high-energy electrons often results in disintegration of the deuteron. In this paper, using a simple model of the deuteron, we have calculated the number of electrons scattered at various angles and the energy loss after such a reaction. This model assumes that the electrons interact with each nucleon independently of the other through their electromagnetic fields (impulse approximation). The probability that an electron scatters into a given angle and energy range is then the sum of the probability due to the proton alone and that due to the neutron alone.

The proton and neutron are considered as extended bodies with distributions of charge and magnetic moment, and with a distribution of momenta. The results depend significantly on the neutron structure, which is not well known. We have computed the pattern of scattered electrons for several different neutron distributions and compared them with the results of other more precise and lengthier calculations. These results agree, indicating that the above-described model of the deuteron is valid. Extensive computations have also been made for comparison with experiment.

This work was supported in part by the U.S. Air Force through the Air Force Office of Scientific Research.

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On the Exponents of a Simple Compact Lie Group

Finding what remains invariant under a group of transformations is a classical problem in mathematics. One such problem which has attracted considerable attention is as follows: If G is a simple, closed, continuous group (simple compact Lie group), what can one say about the polynomials in the infinitesimal generators of G which remain invariant under the transformation $x \rightarrow b \times b^{-1}$ of G itself for all b in G. Much of the early work on this question was done by the mathematician Casimir and the physicist Racah. One knows that all such polynomials are generated by a finite number of primitive polynomials, the degrees of which, $m_1, m_2, \ldots mr$ are called the exponents of G. A surprising turn came when, in 1950, C. Chevalley, at the International Congress in Cambridge, showed that the invariant symmetric theory in the infinitesmal generators is essentially the same as the antisymmetric theory. This meant one could determine the exponents from the Betti numbers of G. In fact, as a consequence, the Poincaré polynomial of G is just

$$(1 + t^{2m_1-1})(1 + t^{2m_2-1}) \ldots (1 + t^{2m_r-1}).$$

Upon learning from Chevalley what the exponents were in special cases, H. Coxeter came upon a remarkable coincidence. He was able to read these numbers off directly from the eigen values a particular transformation in a finite reflection group (Weyl group) associated with G. No explanation for this phenomenon was given. Subsequently, using an entirely different approach, R. Bott obtained the exponents by applying Morse theory to a study of the geodesics on G. Thus three unrelated methods were found to yield the exponents of G, and one of them was only empirical.

Here we announce a direct proof of the equivalence of these methods. Principally we establish the validity of the method of Coxeter. (In doing so we settle certain questions on finite reflection groups.) The major step is to relate the observations of Coxeter with the proof of Bott. The link between these two is played by the principal three-dimensional simple subgroup, a subgroup discovered (and used for other purposes) simultaneously by Dynkin and de Siebenthal.

BERTRAM KOSTANT
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Occurrence of Aluminum Hydride Emission in Spectra of Long-Period Variables

In the vicinity of minimum light, the long-period variables χ Cygni and R Cygni show an intense emission-line spectrum, of which a prominent constituent is the $A^1\Pi - X^1\Sigma +$ system of the aluminum hydride molecule. The AlH spectrum is not complete, but occurs only as short series of rotational lines in each band branch; this has been explained as due to the formation of AlH molecules by inverse predissociation. It is known that some long-period variables show no AlH emission, and the present investigation was designed to discover the rules of its occurrence. The spectra of some 70 long-period variables have now been observed near minimum light with low dispersion at the Crossley reflector. An intense display of AlH emission has been found in just eight of these stars. The conclusions are:

1) The AlH phenomenon occurs strongly only in S-type variables. It has been observed in no stars of period shorter than 370 days, but all those of period longer than this value show AlH emission near minimum light.

2) The intensity of the AlH lines does not seem to depend upon whether the star is a marginal or an advanced S type, upon its light amplitude, or upon any other obvious characteristic.

3) Although AlH emission appears weakly in a few M-type variables, no occurrence of comparable intensity with that in the S stars has been observed among the pure M types.

GEORGE H. HERBIG
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Individual Differences in Susceptibility to Hypnosis

While it is well known that among cooperative subjects some are much more readily hypnotizable than others, there is little firm knowledge about the distribution of susceptibility within the population or about the personality correlates of susceptibility.

The susceptibility of 74 subjects has been studied by attempting to hypnotize them individually by a standard procedure. Because the subjects volunteered for another kind of experiment, the bias introduced by their volunteering for an experiment in hypnosis has been avoided. Results for these subjects are compared with results from a sample of 200 subjects tested by others at the University of Michigan. The measures of susceptibility prove to be highly consistent internally, and preliminary work with another sample shows them to have satisfactory retest reliability.

The form of the curve of distribution of susceptibility fluctuates with the items entering into the scale of measurement and with the relative weights assigned. In view of the high intercorrelation of many of these items, a bimodal curve results if the scale is limited to these items.

Preliminary to preparing a personality inventory that will predict susceptibility to hypnosis, the subjects scoring high and low in the susceptibility experiment have been interviewed by a psychiatrist. At least one syndrome emerges: The highly susceptible men are predominantly well-adjusted, outgoing students, identified with their successful fathers, and capable of assuming both the role of leader and the role of follower.

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Biological Implications of Abortive Reproduction of Animal Viruses

The reproduction of swine influenza virus, like that of influenza A, influenza B, and mumps viruses, yields a high proportion of infective particles when the number of particles inoculated is less than 0.2 per cell. When the number is greater than 2 per cell, more than 95 percent of the particles produced are noninfective. Reproduction that leads to the production of noninfective virus particles may be designated abortive.

With each of the four viruses, the proportion of new particles that are noninfective increases progressively as the number of particles inoculated is increased beyond 2 per cell. Initial particle-cell ratios of 20 lead to the production of virus particles 99 percent or more of which are noninfective. Abortive reproduction is not related to the instability of the infective property of the virus particle. Although influenza A, influenza B, and mumps viruses are highly unstable, swine influenza virus has an infective half-life of about 22 hours at 35°C.

Regardless of the number of particles inoculated, the reproduction of mumps and the three influenza viruses leads eventually to the production of new particles in numbers that greatly exceed those necessary for the induction of abortive reproduction. This results in a relation which has the aspects of a feedback mechanism; the larger the number of virus particles that are produced the smaller is the proportion that are infective. Under these conditions, the reproductive process cannot perpetuate itself and the infection leads to a spontaneous cure.

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Metallic Conduction of Nonmetals at High Pressures

There are two possible mechanisms by which a nonmetal may be converted into a metal under the influence of high pressures. First, under the influence of high pressure, the kinetic energy of the electrons can be increased until it is greater than the binding energy. Second, the band theory predicts that if the valence bond intersects the conduction bond a metal must result. The pressures required by the former appear to be greater than those presently available for a laboratory experiment. Electronic transitions have been reported by Bridgeman for cesium, cerium, tellurium, and silver sulfide. Alder and Christian have reported that a number of solids become conducting at high pressures obtained by shock waves.

In these experiments the resistance was determined as a function of pressure. At pressures of 160,000 atm the maximum specific resistances of phosphorus and silver oxide had a value of 600×10^{-6} ohm cm. Certain measurements indicate that the value may be as low as 20×10^{-6} ohm cm. The most likely value is 100×10^{-6} ohm cm. This conductivity is somewhat better than that of bismuth at atmospheric pressure. These data strongly indicate that both phosphorus and silver oxide have become metallic at these pressures. At present the gap in phosphorus is being studied as a function of pressure.

The behavior of iodine has been studied to a pressure of 200,000 atm. At atmospheric pressure the specific resistance of iodine is above 10^{10} ohm cm. This is reduced to 10^{-2} ohm cm at the highest pressure that we have studied. The resistance is still decreasing with pressure. Unless there is a phase transition, iodine will become metallic at room temperature at a pressure on the order of 400,000 atm.

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Kinetic Isotope Effect Involving Methyl Radicals

The complete set of eight reactions of the type

$$x_3C + y - z \rightarrow x_3C - y - z \rightarrow x_3Cy + z$$

(where x, y, and z are permuted between H and D) has been studied experimentally by Whittle and Steacie [*J. Chem. Phys.* **21**, 993 (1953)] over a range of temperature. The six-atom activated complex with an axis of threefold symmetry is sufficiently simple to permit a complete vibrational analysis. This complete analysis has been used to find a suitable equivalent four-atom complex. For a single set of force constants, deduced from considerations of molecular structure and molecular spectroscopy, a complete set of frequencies for eight activated complexes was computed, the mass along the reaction coordinate was found, and the kinetic isotope effect was evaluated by Bigeleisen's formulation of the activated complex

theory. Except for certain small trends, believed to correspond to internal inconsistencies in the experimental data, there is satisfactory agreement between theory and experiment for 18 different ratios of rate constants between 403° and 563°K.

HAROLD S. JOHNSTON
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Brain Chemistry and Adaptive Behavior in the Rat

In a continuing study of the relations between adaptive behavior and brain chemistry, we have tested several strains of rats in various learning situations. On all learning tasks, the S_1 strain (descendants of Tryon's maze-bright animals) is superior to the S_8 strain (descendants of the Tryon's maze-dull animals).

The S_1 rats are also found to have significantly greater cholinesterase (ChE) activity than the S_8 rats in both cortical and subcortical brain. This difference may be specific to ChE, since in other enzymes tested no strain differences appear.

To determine whether the observed relationship between ChE and learning capacity might be merely fortuitous, several genetic experiments were undertaken. First, a cross between the S_1 and the S_8 strains (the K strain) was tested on standard learning problems, and individual performance records were compared with individual ChE activity levels. Second, through selective breeding, two lines of rats high in ChE, and two lines low in ChE (the R strains), were developed. We have now begun behavioral tests of these animals.

The results of the tests with the K and R rats indicate that while ChE is definitely related to learning ability, the relationship is not a simple linear one.

On the basis of the data, a hypothesis is suggested which relates learning capacity to the acetylcholine-cholinesterase balance in the central nervous system. Proposals for further empirical checks of this hypothesis are then discussed.

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Radiation in High-Energy Electron-Proton Collisions

The radiation of a photon is one of the dominant processes competing with the production of a π-meson when a high-energy electron loses energy in a collision with a proton. The energy and angular distributions of the scattered electron, as observed by experiments at Stanford, are affected by both processes. The meson production process is of prime interest since it depends sensitively on neutron structure. However, an accurate determination of the radiation process is necessary to facilitate this investigation of the neutron's size.

Our calculation endeavors to provide this theoretical knowledge of the scattering contribution resulting from the radiative process by employing the well-known formalism of quantum electrodynamics. Our standard treatment of the dynamical effects of proton recoil employs fewer approximations than earlier calculations, and the effect of recently acquired knowledge of the proton's charge and magnetic-moment structure is also included. Certain higher orders of approximation, involving multiple photon processes and meson interactions, have not been considered, but are estimated to limit the accuracy of our result by about 5 percent at the highest energies in the range of interest. Our results, except for small deviations at lower energies, are in substantial agreement with earlier calculations.

This work was supported in part by the U.S. Air Force through the Air Force Office of Scientific Research.

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Quantitative Tests of the 120-Inch Mirror of Lick Observatory

During the final stages of the figuring process, the 120-inch mirror was tested in the telescope on stars. Quantitative Hartmann tests were carried out in addition to standard knife-edge tests. The latter were made by D. O. Hendrix, who was in charge of figuring the mirror.

Instead of the conventional tests by zones [J. Hartmann, *Z. Instrumentenk.* 24, 1, 33, 97 (1904)], local and detailed departures of the mirror from a paraboloid were determined. Originally only radial profiles were derived, but it was found that in the presence of appreciable astigmatism and local errors, a common zero-level for different radial profiles could not be established. A more elaborate procedure had to be developed by supplementing the conventional radial measurements with tangential ones.

Measurements of the 192 images of holes in the Hartmann screen gave 384 equations of condition, from which normal equations were formed for determination of the best-fitting paraboloid. The extrafocal image of the Hartmann screen, as formed by this paraboloid, was then computed and compared with the measured one, and radial as well as tangential deflections in the focal plane were derived from the comparison. Integration of these deflections yielded radial and tangential profiles of the departures of the mirror surface from an ideal paraboloid. The closed tangential profiles permitted establishment of a common zero-level for all the profiles. After the latter were reconciled, it was possible to draw a contour-map of the mirror. A rapid improvement in the mirror figure resulted from the availability of this detailed information to the opticians. The mirror is now free from astigmatism, and its figure compares favorably with those of the best large telescope mirrors.

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Lick Observatory

Production and Reproduction of the Mitotic Apparatus

The isolation of the mitotic apparatus (MA) in analyzable quantities from synchronously dividing cells (sea urchin eggs) has made it possible to put certain questions concerning the physiology of mitosis in chemical terms. Analyses of the MA as isolated by our earlier methods have yielded the following general facts. (i) The fully formed MA, according to the data of Mazia and Roslansky, comprises 10 percent or more of all the protein in the cells studied. (ii) By electrophoretic and ultracentrifugal criteria, the MA is composed largely of a single species of protein, but a second component, larger and more negatively charged, is always found in smaller quantities. (iii) The major component is a protein of average molecular weight about 315,000 (data of A. M. Zimmerman). (iv) Ribonucleic acid (RNA) is always present. Recent analyses by A. M. Zimmerman give an RNA content of 6 percent and show the presence of all four nucleotides of RNA. (v) Evidence from solubility studies as well as from observations with certain mitotic inhibitors suggests that S—S bonds (or other bonds involving thiol groups) are involved in the protein-to-protein linkages by which the mitotic apparatus is assembled.

In the living cell, the MA is a highly unstable structure, and all earlier attempts to isolate it directly from living cells have failed. The hypothesis that the coherence of the MA depends on S—S bonds predicts that it may be stable only when these are "protected." Such stabilization might be achieved, reversibly, in the presence of another S—S system. On the basis of this prediction, a successful method of isolation of the MA directly from living, dividing sea urchin eggs has been developed recently in collaboration with J. M. Mitchison, H. Medina, R. Iverson, and P. Harris. The isolation is made directly in isotonic dextrose containing dithiodiglycol. The "native" MA so isolated is stable only in the presence of dithiodiglycol. Its properties are under study.

The characterization of the proteins of the MA has permitted an approach to the question whether the substance of which it is composed is a new species synthesized as the MA forms or whether it exists before division and is merely assembled as mitosis proceeds. In experiments by H. A. Went, antibodies to the extractable proteins of the unfertilized egg and to the isolated mitotic apparatus were prepared, and the Ouchterlony gel-diffusion technique was employed to determine whether the unfertilized egg contained an antigen identical with that characteristic of the protein of the mitotic apparatus. The MA yielded a single antigen which matched one of the several antigens of the eggs extracted before division. These results favor the hypothesis that the proteins of the MA are preformed before division and are assembled at division.

The evidence of a decisive role of S—S bonds in the formation of the MA predicts that an excess of a nontoxic —SH compound capable of penetrating the cell

readily should block mitosis reversibly. In studies with mercaptoethanol this prediction was verified. However, if cells were blocked until the time when the next division was expected normally, and the block was then reversed, they divided directly into four cells. Apparently the reproduction of the mitotic apparatus, based on the reproduction of the centers, proceeds even when it cannot function.

DANIEL MAZIA
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On the Stellar Population of the Nuclear Region of the Galaxy

Spectrograms of integrated starlight in four regions near the nucleus of the Galaxy have been obtained recently at the McDonald Observatory. These indicate that the principal contributors to the light of the nuclear region are stars of solar and later type. The general stellar population by luminosity of the nuclear region is therefore different from that of the globular clusters of the Galactic halo.

A comparison of the Galactic nuclear region with that of the Andromeda nebula suggests a probable large-scale structural difference, although the two systems are of the same general class.

W. W. MORGAN
University of Chicago

Atomic Beam Research on Radioactive Atoms

The fundamental purpose of the research is the measurement of the spin, magnetic dipole, and electric quadrupole moment of radioactive nuclei whose half lives lie in the range 20 minutes to 25,000 years. The results are of particular importance in the field of nuclear structure, for most nuclei lie in this range and many of them lie far from the line of stability. The total number of such nuclei treated at Berkeley is approximately 60.

A number of very difficult problems had to be solved, mostly related to the very small number of atoms, as low as 10^{10}, that could be manufactured. These problems involved developments in the atomic beam equipment itself, isotope production at the cyclotron, radiochemistry suitable for beam work, beam collection techniques, and special counting techniques. As an example, x-ray counters were developed that yielded an over-all efficiency of about 40 percent with a background as low as 0.3 count/min.

The first measurements were made on the neutron-deficient isotopes of rubidium and cesium and were soon extended to thallium, indium, silver, gold, copper, and other elements whose atoms are characterized by an electronic angular momentum of 1/2. This is the situation of maximum signal intensity. Quadrupole moments of atoms in this ground state are not susceptible to measurement, and parallel research was undertaken on the radiohalogens whose electronic ground state has an angular momentum of 3/2. A considerable number of isotopes of bromine and iodine have been measured, including Br^{76}, which is the first observed case of hyperfine levels that are not in the normal order. Astatine (211) has been a successful special case of the halogens.

Another important result of these techniques is the determination of the electronic characteristics of the atoms in those cases where there was insufficient prior information on this point. In this connection, there has been particular success in the case of the heavy elements, such as protactinium, neptunium, plutonium, americium, and curium, where the spectroscopic ground state characteristics have been determined as well as the nuclear properties.

The senior members of the group associated with this research are J. C. Hubbs, E. Lipworth, H. A. Shugart, and H. A. Silsbee.

W. A. NIERENBERG
University of California, Berkeley

Mechanisms for Dehydration

The role of β-hydroxy ketones and β-hydroxy acids in organic synthesis is well known. We have undertaken a study of the rate of dehydration in aqueous acid for representative members of these classes of compounds.

The rate of formation of substituted cinnamic acids from β-aryl-β-hydroxypropionic acids is very sensitive to the substituent in the aromatic ring. The reaction is strongly acid-catalyzed.

Quite in contrast, the dehydration of β-aryl-β-hydroxybutanones shows little sensitivity to variations in structure. The rate of dehydration shows a lesser sensitivity to acid concentration, which parallels the rate of enolization of simple ketones.

The consideration of these results and others previously reported provides very strong evidence for the operation of two mechanisms of dehydration in each series of compounds. Rate-determining enolization is the usual mechanism for dehydration of β-hydroxy ketones; suitable compounds undergo dehydration via a carbonium ion mechanism. For β-hydroxy acids, a carbonium ion mechanism is observed in most cases; suitable compounds appear to undergo dehydration via enolization.

D. S. NOYCE, P. A. KING, W. L. REED
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Infrared Detection of the Free Radical NH_2

In earlier work the photolysis of hydrazoic acid suspended in solid nitrogen, argon, and xenon at 20°K revealed spectral features certainly associated with unstable intermediate species which react upon diffusion [E. D. Becker, G. C. Pimentel, M. Van Thiel, *J. Chem. Phys.* **26**, 145 (1957)]. The present work is directed toward the critical test of the proposed explanation that NH_2 was formed by the reactions

$$HN_3 + h\nu \rightarrow NH + N_2 \quad (1)$$
$$NH + HN_3 \rightarrow NH_2 + N_3 \quad (2)$$
$$NH_2 + HN_3 \rightarrow NH_3 + N_3 \quad (3)$$

and that NH_2 was detected by the infrared absorption of its bending mode at 1290 cm^{-1}.

Hydrogen bonding by HN_3 provides a possible explanation of the observed absorptions alternative to the assignment to free radicals. Hydrogen bond formation of the type $HN_3 \cdots HN_3$ and also with ammonia, $H_3N \cdots HN_3$, was studied, and in each case the hydrogen bond causes spectral changes. These changes do not, however, account for the new features which are obtained when HN_3 is photolyzed in solid nitrogen.

A second critical test of the proposed interpretation relates to the effect of concentration of hydrazoic acid in the matrix. At lower concentration the production of ammonia through reaction 3 should be inhibited relative to reaction 2. An experiment was performed at the lowest concentration experimentally feasible. Photolysis again produced the spectral features of ammonia and showed distinctly the reduction of diffusional processes. The formation of the band at 1290 cm^{-1} was apparently not affected.

The most informative test of the proposed identification of NH_2 is the preparation of the deuterated counterparts. For this purpose DN_3 was prepared and photolyzed. The absorption at 1290 cm^{-1} was not produced, but new absorptions were observed at lower frequencies appropriately shifted to be assigned to NHD and ND_2.

In summary, all of the experiments performed substantiate the conclusion that the NH_2 radical has been detected for the first time by infrared absorption.

GEORGE C. PIMENTEL
MATHIAS VAN THIEL
University of California, Berkeley

Diurnal Cycles of Man and Animals

Little is known about diurnal cycles of man except for the waking-sleeping cycle of day and night. The results of recent studies made in this and other laboratories on animals kept in constant light or darkness, or after blinding or destruction of visual mechanisms of the brain, may throw light on the factors underlying the diurnal cycle of man.

The rat lends itself well for these studies since continuous records can readily be obtained of its spontaneous activity (by means of a revolving drum) and food and water intake.

The rat is nocturnal and usually starts its one daily more or less continuous period of activity shortly after the onset of darkness and ends it shortly before dawn. After enucleation or occipital lobectomy each rat may show its own internal cycle of diurnal activity—that is, its one daily period of activity may begin earlier each day by as much as 60 minutes, or later each day by as much as 40 minutes. This

means that, with successive days or weeks, the daily period of activity may start during the day or even extend over the entire day, while in the dark the rat is completely inactive. One rat after enucleation has now for many months begun to run earlier each day by almost exactly 26 minutes regardless of the noise and other disturbances caused by other rats and by laboratory workers.

The length of the diurnal cycle is independent of the effects of treatment with various drugs and external conditions, especially temperature, but it can apparently be influenced by unknown cosmic agents, by removal of the olfactory bulbs, and by thyroxin.

These observations on the rat and other animals may throw light on the diurnal cycle as seen in man under pathological as well as normal conditions. They may help, for instance, to explain the mystery of the inverted sleeping-waking rhythm of some patients with lethargic encephalitis.

CURT P. RICHTER
Johns Hopkins Hospital

Contributions toward the More Accurate Calculation of Atomic Properties

For atoms with more than one electron it has not been possible to solve exactly the quantum mechanical equations of motion. Various perturbation and variation techniques are available to help in the search for accurate approximations to the wave functions. The most widely and successfully used approach is the Ritz variational method which gives the most accurate approximation to the energy of the system. However, as has been long recognized, the approximate wave function derived by this method may be relatively inaccurate for the computation of other properties of the system. By a particular application of the well-known perturbation theory we have found a method for improving these calculations which requires only moderate computational effort. The general prescription presented is of a formal nature, yet solutions have been found for a number of problems based on the simple one-electron atom. From this starting point good calculations of several properties of the two-electron atom have been carried out, and further applications are being attempted.

This work was supported in part by the U.S. Air Force through the Air Force Office of Scientific Research.

CHARLES SCHWARTZ
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Differential Mitotic Response of Diploid and Polyploid Nuclei to Auxin and Kinetin Treatment

During the course of tissue differentiation in pea roots, chromosome doubling is the usual concomitant of cellular maturation. Polyploid nuclei resulting from endomitotic reduplication divide infrequently and in such cells differentiation leading to mature cell types proceeds. In experiments on the intitiation of callus tissues from excised segments of mature pea root tissues, it was found that the occurrence of mitoses in either diploid or polyploid nuclei in the tissues was dependent upon the constituents of the nutrient medium provided. On a yeast extract-auxin medium, tetraploid mitoses predominate, although infrequent mitotic figures of diploid, octaploid, and higher ploidy level also occur. On a synthetic medium containing the auxin, 2,4-D, but in which yeast extract is replaced by a known mixture of vitamins and organic nitrogen sources, only diploid mitoses are found, although cells with polyploid nuclei are known to occur in the tissues.

A study has been made to determine the factors in the yeast extract-auxin medium, but lacking from the synthetic medium, which stimulate mitoses in cells with polyploid nuclei. Additions of nucleic acid constituents were made to the synthetic medium on which mature root tissue segments were cultivated, and Feulgen squashes for cytological study were prepared periodically. Yeast nucleic acid and individual purines and pyrimidines tested were ineffective in inducing mitoses in polyploid nuclei. Kinetin (6-furfuryl amino purine), when it is added to the synthetic medium at $5 \times 10^{-6} M$, initiates frequent mitoses in tetraploid nuclei which otherwise would remain in the resting state. Thus, in diploid and polyploid cells of the same tissue system, physiological differences of considerable importance to cell differentiation are demonstrable.

JOHN G. TORREY
University of California, Berkeley

Certain Aspects of the Biology of Mouse Runways

Through the use of automatic, repeating photographic recorders the traffic in natural runways of mice in the wild has been investigated. During 19 months 8495 passages of 27 species of vertebrates were recorded, mostly meadow mice (*Microtus californicus*) and harvest mice (*Reithrodontomys megalotis*). The average was 11 passages per runway per 24 hours.

Meadow mice provided an average of 7.8 passages per 24 hours and a maximum of 67. During weekly periods the average number of meadow mice using a runway was about six. Single individuals passed along a runway as many as 45 times in one day. Male meadow mice provided more passages per individual than females did. The average duration of excursions from underground retreats out into runways and back was 5 minutes. Daytime excursions were longer than those at night, and excursions by females lasted longer than those by males.

Traffic in the runways was not noticeably greater when the general population of meadow mice was high than when it was low. It appears that the population increases by multiplication of occupied runway systems rather than by an increase in the number of individuals in runways already occupied. In this manner the population can increase many fold without causing a great increase in the number of contacts between individuals. This is relevant to the question of the natural control of populations by the frequency of contacts and the consequent "stress."

OLIVER P. PEARSON
University of California, Berkeley

Application of Digital Computers to the Reduction and Analysis of High-Dispersion Molecular Spectra

The reduction and analysis of the rotational fine structures of highly resolved molecular band spectra involve several very laborious and time-consuming operations, even when the spectra are relatively simple in structure. Among these operations are the calculation of the vacuum wave numbers from the line measurements and the identification of the branches into which the component lines of individual bands may be divided. The latter step becomes very difficult, if not impossible, if the spectra are complex, with severe overlapping of bands.

Programs have been developed for the I.B.M. 701 computer on the Berkeley campus by which both of the operations mentioned above may be carried out automatically. Since, in general, the molecular constants determining the band structures are unknown, the program of analysis makes use of the fact that the locations of lines within any particular branch correspond approximately to a second-order equation, so that two successive lines can be found with a wave-number difference which is close to any arbitrarily chosen wave-number interval. The computer searches for all branches satisfying second-order equations with coefficients lying within arbitrarily chosen ranges.

The programs have been successfully tested on a sequence of bands of the Swan system of the C_2 molecule and on a complex region of the TiO spectrum between 6200 and 6500 A.

JOHN G. PHILLIPS
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Adrenal Hypercorticalism in Spawning Pacific Salmon

Death of all the Pacific salmon shortly after their first spawning presents a problem of unusual interest since this is an almost unique phenomenon among vertebrates (the phenomenon is unknown in mammals and is rare in fishes).

Histological studies of the various organs and tissues of the spawning salmon revealed markedly increased functional activity of the pituitary gland during the maturation of the gonads, followed at spawning by degeneration. At the same time the adrenal cortical tissue exhibited pronounced hyperplasia. Widespread atrophy and degeneration was found among other organs: stomach, liver, spleen, gonads, thyroid, and vascular system. Studies of the blood plasma revealed a high concentration of catabolic adrenal

corticosteroids, 3 to 7 times that present normally in sea salmon. Associated with the increase in circulating adrenal steroids were hyperglycemia, lowered plasma proteins, reduced gamma globulin concentration, and disappearance of lymphocytes from the spleen. Such findings are consistent with adrenal hypercorticalism.

It has been possible to produce in immature rainbow trout, by means of hydrocortisone implanted in cholesterol pellets, almost all the degenerative changes characteristic of the spawning salmon. All the fish so treated died in 3 to 4 weeks. There are striking similarities between the clinical and pathological findings in the spawning salmon and Cushing's syndrome in man.

O. H. ROBERTSON
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New Mechanism of Temperature Adaptation in Plants

In earlier work on the effects of temperature on tomato plants, it was found that the relatively low optimal temperature for growth and fruit set is due to an interaction between a temperature effect with a Q_{10} of 2 to 3 on growth processes and one with a Q_{10} of about 0.8 on sugar translocation.

After it was established that for optimal growth of tomato (both in length and in weight) and other plants, the plants should be subjected to a succession of light and darkness on a 24-hour cycle basis, the optimal length of this cycle was determined at different constant temperatures. A large number of individual experiments unequivocally show that at the optimal range of temperature for growth (20°C) the optimal cycle length is 24 hours, but at 15°C it is about 28 hours, and at 30°C it is 18 hours. Therefore, the cycle length for optimal tomato growth has a Q_{10} of 1.25. Practically the same value for Q_{10} was found for nyctinastic movements of *Phaseolus* leaves, growth of *Baeria chrysostoma,* and development of *Saint-paulia ionantha.*

F. W. WENT
Missouri Botanical Garden

New Method for Determination of Distances of Late-Type Stars

One of the fundamental problems of astronomy is the accurate determination of the distances of stars. Since the apparent brightness is relatively easy to measure, this problem is, in general, solved if the true, or intrinsic, luminosity can be found by some means. The classical method is the measurement of trigonometric parallax, but only for a relatively few nearby stars can this procedure yield accurate results. For a few groups, such as moving clusters, combinations of proper motion and radial velocity determinations give accurate distances. Spectroscopic methods, calibrated by the more fundamental ones, can give good average values but, except for main-sequence stars, individual determinations are often of rather low accuracy.

The great majority of stars of spectral type G0 and later show a bright reversal at the centers of the wide dark H and K lines of Ca II. It has been found that the widths of these emission features correlate with the absolute luminosities for all stars from dwarf M-type stars to the supergiants —that is, over a range of brightness of at least 15 magnitudes. At present, efforts are being made to test the accuracy attainable in this manner. The method is calibrated by using the sun and the four bright Hyades stars whose luminosities are known from cluster motions. Results obtained so far indicate that, by reducing observational error, absolute luminosities good to one- or two-tenths of a magnitude can be obtained. If this expectation is supported by further investigation, this procedure will have many valuable applications.

O. C. WILSON
Mount Wilson and Palomar Observatories

Gas-Liquid Partition Chromatography—Some Theoretical and Engineering Considerations

A theory of elution chromatography is proposed for the design of large-size chromatographic columns. In this theory, an equilibrium linear isotherm is assumed to be the mass-transfer mechanism, and dispersion of the solute band is attributed to longitudinal diffusion.

The theory was tested for elution of acetone, benzene, and toluene with helium in a small gas-liquid chromatographic column packed with 30- to 60-mesh fire brick containing a silicone oil. Tests were conducted at 100 lb/in.^{2} (gage) over a range of Reynolds numbers from 0.2 to 1.8. Although agreement between theory and experiment is not completely satisfactory, the results indicate that longitudinal dispersion may be a major cause of band spreading.

On the basis of the method a preliminary plant design and economic evaluation were made for production of ethyl benzene, zene, *m,p*-xylene and *o*-xylene from a hydrocarbon mixture.

C. R. WILKE
ROBERT H. HOUSTON
ANDREAS ACRIVOS
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Physical Model of Nova Aquilae 1918

The position of a nova in the scheme of stellar evolution is briefly indicated. The nova mechanism provides for ejection of mass and, hence, permits a star to progress toward the final white dwarf stage. No satisfactory explanation of the nova mechanism exists; a study of the detailed pattern of ejection may give some clue to the nature of the mechanism.

Nova Aquilae 1918 provides an excellent case for a study of the details of the ejected shell. The observable structure of the spectral lines can be related to the physical structure of the shell. The shell consists of a series of rings, or, more precisely, of truncated cones of remarkable symmetry with respect to what may be termed the "poles" of the star. Light oscillations in the transition portion of the light curve are related to activity on the star alternating between the poles and the equator.

It may be shown that radiative excitation cannot account for all the phenomena observed in the spectral lines. Collisional excitation must play an important role in the production of the observed radiation.

HAROLD F. WEAVER
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Gravitational Properties of Antimatter

A very precise series of experiments involving gravity was performed by Eötvös and collaborators between 1890 and 1922. These show, with an accuracy of about 1 part in 10^8, that the ratio of gravitational to inertial mass is the same for several substances scattered throughout the periodic table. A general discussion will be given of the inferences that can be drawn from these experiments in regard to the gravitational interactions of matter and antimatter, with and without the assumption that experiments performed in a hypothetical "antilaboratory" yield the same results as those performed in the laboratory. In particular, it will be shown that the Eötvös experiments preclude the possibility that the gravitational mass of a positron is equal to and opposite in sign from that of an electron. This conclusion follows from a consideration of the effect of the earth's gravitational field on the virtual positrons produced because of the polarization of the vacuum by the Coulomb field of an atom. If the total energy of the virtual positrons has anomalous gravitational properties, the difference between the gravitational and inertial masses of the atom is logarithmically divergent. If, on the other hand, only the positron rest mass is anomalous (not the kinetic energy), the mass difference is finite, and is 10 to 30 times larger than that permitted by the Eötvös experiments.

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