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New Systematics in Alpha-Radioactivity

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A great number of new nuclear species have been prepared within the last few years in the region of the natural radioactivities, permitting a more extensive view of the nuclear properties here. In particular, regularities in alpha-decay properties can now be seen more clearly. More recently, work in this laboratory with the 184-inch cyclotron has further extended our view of alpha-decay properties by identifying isotopes of the elements in this region far on the neutron-deficient side of beta-stability.

One particularly interesting correlation of these data shows that each element from bismuth to curium has a parallel increase in alpha-energy with decreasing mass number, starting with the heaviest isotope of each. In the cases of thorium and uranium this regularity extends through 8 measured isotopes covering mass number ranges of 9 and 11, respectively. In the lower elements a different phenomenon appears. Although the heaviest isotopes of each show the trend noted above, the alpha-energies begin to decrease with decreasing mass number beyond a particular point. The isotopes showing maximum alpha-energy are, for the respective elements, Bi^{211}, Po^{212}, and At^{214} or At^{213}, the latter being unknown. This trend was noted some time ago for polonium isotopes. However, at still lower mass numbers for each element the initial trend of increase in alpha-energy with decrease in mass number is resumed.

The Thermodynamics of the System KHF_2, KF, HF, and the Nature of the Hydrogen Bond in KHF_2

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(Introduced by W. M. Latimer)

It was discovered by Pauling and confirmed by Giauque and others that the proton is not symmetrically placed in many O—H—O hydrogen bonds. The shortest and presumably the strongest hydrogen bond known is the F—H—F bond in the ion HF_2^-. The present investigation considered the crystal KHF_2 and the symmetry or asymmetry of proton location therein.

By a sequence of thermal and chemical equilibrium measurements involving the reaction $KHF_2 \rightleftharpoons KF + HF$, it was established that no residual entropy of proton location remains in KHF_2 at the absolute zero. The thermal behavior of KHF_2 shows no low temperature anomaly which might be associated with a long-range ordering of unsymmetrically located protons. Consequently, it is concluded that the proton in the FHF^- ion is centrally located. The relationship of this conclusion to spectroscopic and other related properties of KHF_2 is discussed.

Relative Rates of Hydrolysis of Urea Containing C^{12} and C^{14}

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Urea containing radioactive carbon was synthesized by a simple method which involved releasing carbon dioxide from barium carbonate, mixing with ammonia at a low temperature, driving the resulting ammonium carbonate into a capillary tube, sealing off, and heating for two days at 135°.

About 0.1 gm of the urea containing both C^{12} and C^{14} was dissolved in 20 cc of buffered solutions ranging from pH 4.9 to pH 6.7. The urea in the presence of the enzyme urease hydrolyzed to give ammonia and carbon dioxide. The carbon dioxide was swept out with a rapid stream of purified nitrogen and absorbed in standard barium hydroxide solution. The course of the reaction was followed by back-titration of barium hydroxide solution, and samples of carbon dioxide from the early, middle, and late periods of the reaction, precipitated as barium carbonate, were analyzed for C^{14} with a Geiger-Müller counter. The carbon dioxide evolved in the latest stages of the reaction was found to be depleted with respect to radioactive C^{14}. If the difference in zero-point energy of C^{12} and C^{14} bonds in the original urea were the *only* factor affecting the competing reaction rates, the urea containing C^{14} should have reacted more slowly, leading to an enrichment rather than a depletion of C^{14} in the late stages of the reaction. The possibilities of other factors are considered.

Some Results Obtained With the 184-Inch Cyclotron

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The first two years of this great machine's operating life have been marked by a wide range of experimental activity. The cyclotron provides nuclear projectiles with energies up to nearly 400 Mev; when these strike other nuclei, many things happen, some of them being strikingly different from phenomena previously observed at lower energies. Most of the processes seen can be described in terms of rearrangements of the neutrons and protons that are supposed to be the fundamental constituents of nuclei, and a detailed study of these processes has already led to a considerable clarification of our ideas concerning the forces that act between these particles. In some

cases, however, different particles come out. These have been found to be mesons, previously seen only in the cosmic rays. Here the interpretation is by no means so clear, and perhaps the next great advance in knowledge will come when further work has shown the true nature of these events.

A Progress Report on the Cyclotron

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At the last meeting of the Academy in Berkeley the basic principle of the cyclotron was outlined, and the first experiments with a 4-inch magnet were described. The present paper is a general review of the development of the cyclotron during the intervening 18 years, including the 184-inch synchrocyclotron and the 100-foot betatron, both of which are special applications of the principle of the synchrotron of McMillan and Veksler.

The Berkeley Linear Accelerator

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The initial performance of the accelerator was described somewhat over a year ago. At that time the operation was very erratic, and the beam current was about 10^{-11} amp. The reliability of operation now corresponds to that of an average cyclotron and is being improved continuously. About 95% of the time the Van de Graaff injector is operating, 32-Mev protons are available, indicating that the high-frequency part of the accelerator is remarkably free from trouble. In one month a Van de Graaff beam was available 80% of the working hours, and a figure of 90% is expected in the near future. The beam current now averages 10^{-9} amp. A program to increase this to the neighborhood of 1 microamp is now under way and involves four straightforward features: (1) The focusing grids have been made more transparent; (2) the duty cycle of operation is being increased; (3) the entering ions are being bunched into a smaller phase angle by radiofrequency techniques; and (4) a new ion source is being installed. When the improvement factors of these four programs are multiplied together, the result is of the order of 10^3. The research program now under way includes measurements on proton-proton scattering, inelastic scattering of protons, radioactivity, activation thresholds, and nuclear cross sections. The most attractive feature of the machine is the highly collimated external beam (diameter, 3 mm), which is relatively free of background radiation.

The Magnetic Moments of Light Nuclei

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It has been recognized for a considerable time that one can ascribe to the atomic nucleus a definite value of its angular momentum as well as of its electric and magnetic moments. The first determinations of these quantities were obtained by spectroscopy and were restricted to the nuclei of the heavier elements.

More recently new methods have been developed which are more accurate and which can also be applied to the lightest nuclei. The interest in the results lies in the fact that they are more directly related to the fundamental problems of nuclear forces than those obtained for the rather complex heavier nuclei.

The most important information concerns the magnetic moments of the neutron and the proton themselves, since they represent the elementary constituents of nuclear matter. It has been possible to compare them with an accuracy of one part in 20,000; together with an earlier determination of the proton moment, this establishes each of these moments to within a fraction of one per mil. Closely related to these values is the magnetic moment of the simplest composite nucleus, that of the heavy hydrogen atom. The corresponding measurements reveal deviations from additivity of the individual moments which are significantly related to the symmetry properties of nuclear forces.

Other interesting features have emerged from the measured magnetic moments of the hydrogen and helium isotopes of atomic weight 3.

Recurrent Geomagnetic Activity

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and

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Periods of moderate geomagnetic activity, generally called moderate magnetic storms, sometimes recur at 27-day intervals. The rotation of the sun has been suggested as the cause of this recurrence, and extensive studies have been made to discover solar features associated with this type of magnetic activity. In 1942–44 the appearances of certain patches of bright chromospheric clouds at the sun's east limb were coincident with relatively abrupt onsets of recurrent geomagnetic activity. Some recurrent magnetic activity has been most conspicuous in the years preceding sunspot minima, not when sunspots were most numerous. Recurrent series also show a tendency to begin when the moon is farthest from the equator, an effect which may be related to asymmetrical lunar tides in the earth's atmosphere.

Economy of Flight at Supersonic Speeds

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(Introduced by J. C. Hunsaker)

The opinion is occasionally expressed that flight at speeds greater than the speed of sound will be excessively wasteful and that such flight is therefore essentially limited, with present sources of propulsion, to military operations. The aerodynamic theory of slender bodies and wings traveling at such speeds indicates, however, that

reasonably good efficiency can be maintained up to moderate supersonic speeds and that the fuel economy in terms of miles per gallon should, with presently available turbojet engines, not fall far short of that achieved by other forms of transportation.

Calculated examples of the air motions produced by wings traveling at supersonic speeds are shown and provide comparison with the air motions produced at normal flying speeds. These comparisons show the origin of the drag which results from exceeding the speed of sound and show how this drag can be minimized by the use of sweepback. Results of such calculations are used to obtain an estimate of the drag and hence the propulsive energy required for aircraft at supersonic speeds. It is found that for efficient flight an airplane of conventional loading must be equipped for operation at an altitude of the order of 60,000 feet. Designing the airplane for high-altitude operation makes it capable of flying slowly at low altitudes for landing.

Rotating Galaxies

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(Introduced by J. H. Moore)

The study of the internal motions in the extragalactic nebulae, or galaxies, is at present in the broad, exploratory stage. About all that can be learned of their dynamics in a quantitative way is how they are rotating. Furthermore, observations are restricted to the measurement, by means of the spectrograph and Doppler's principle, of the rotational motions in the line of sight. Because of the faintness of galaxies, fairly low dispersion (300–400 A/mm) has to be used, and long exposures (up to 12 hrs) are required to photograph spectra only a few millimeters long. As a result of these circumstances, detailed results have hitherto been published for only 5 galaxies.

In an attempt to expand the small but hard-won body of earlier work on rotating galaxies, the present investigation was undertaken. This report is preliminary and depends upon spectrograms of 31 galaxies, ranging in appearance from the unresolved, nearly structureless "early-type" spirals to the highly resolved, "late-type" spirals. In all cases the slit of the spectrograph was placed on the major axes of the galaxies, and within the low precision of the observations, the spectrum lines are found to be straight and inclined by various amounts among the different galaxies. The range in spectrum line inclinations was from a maximum of nearly $5\frac{1}{2}°$ to $\frac{1}{10}°$, the limit of detection with the means at hand. Although the interpretation of these line inclinations in terms of rotation is fraught with difficulties, because of the large-scale integration of motions when the slit traverses a whole stellar system, there is both theoretical and observational evidence to justify it as a working hypothesis. On this basis, periods of rotation could be computed after the distances to these galaxies had been estimated from (a) red shifts in their spectra or (b) membership in well-known groups or clusters of galaxies whose distances were known from other criteria.

The results of the investigation can be summarized in a single diagram showing periods of rotation according to type of galaxy. For a few early-type galaxies (E7, SO, Sa) periods of rotation range from 1,500,000 to 11,000,000 years, no distinction being made between nuclear regions or main body. The large, amorphous nuclear regions of intermediate-type spirals (Sb) rotate in periods ranging from 5,000,000 to 16,000,000 years; their main bodies, in general, are too faint to be observed as a whole. In late-type spirals (Sc) the nuclei are too small for similar investigation, and it is possible to give results only for their main bodies, which appear to rotate in periods ranging from 17,000,000 to more than 250,000,000 years. In short, while there is a general tendency for the period of rotation to lengthen with advancing type, the dispersion in period among the various types is so large that, at least for the present, averages have little significance. Intrinsic brightnesses (absolute magnitudes) likewise seem to bear little relation to period of rotation.

The Electronic Theory of the Transistor

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(Introduced by M. J. Kelly)

The fact that a metal point contact to a crystal of galena will act as a detector of radio waves has long been known. The detection process arises from the fact that the contact is rectifying and passes current more easily in one direction, known as the forward direction, than in the other, known as the reverse direction. The phenomenon of rectification occurs in many other cases in which semiconductors and metals make contact. By analogy with the relationship between vacuum tube diodes and triodes, many unsuccessful proposals have been made over a period of years to incorporate a third electrode in a crystal detector in order to produce an amplifier. This desired result has now been achieved with the development of the transistor, which is based on the new principle described below.

The transistor is similar to a crystal detector except that it has two point contacts very close together rather than one. When the input point, or emitter, is operated in the forward direction, it disturbs the electronic balance in the semiconductor in a certain limited region of interaction, effectively less than 1/100 inch in diameter, in such a way as to give control over the current in the output point, which must make contact in the region of interaction and have voltage in the reverse direction. This control is so effective that power gains of a factor of 100 are obtained.

The disturbance produced in the region of interaction can be understood in terms of the two processes by which electrons carry current in a semiconductor. Both of these processes correspond to imperfections in the complete or perfect electron pair bond structure of the crystal; in the excess process, additional electrons are present over and above those required for the valence bonds, and in the defect or hole process, electrons are missing from the bonds. The germanium used in transistors normally

contains chemical impurities which cause it to conduct only by the excess process, a negligible number of holes being present. When the emitter is operated in the forward or plus direction, it draws not only excess electrons but also electrons from the valence bonds, thus introducing holes which in some cases flow in a thin layer on the surface and in others apparently diffuse into the body of the semiconductor. The presence of these holes constitutes the disturbance about the emitter which produces the area of interaction.

Since the holes are caused by a deficit of electrons, they represent positive charges, and since the output point is biased in the reverse or negative direction, it collects these holes. Thus, the current of the output point, or collector, is increased by the emitter hole current which it collects. In addition to being collected, the holes provoke an increased excess electron flow from the point, and in this way current amplification is produced. Thus, changes in emitter current produce larger changes in collector current. Furthermore, since the emitter operates in the forward or low-voltage direction and the collector in the reverse or high-voltage direction, large voltage amplification is produced. This accounts for the power gain.

The transistor is now in limited experimental production, and research on its application in communications problems is being carried out.

Heterochromatic Inheritance

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Such cytological work as is relevant for a genetic study of heterochromatin is reviewed. Heteropycnotic and intercalary H are distinguished. H is important for mitotic division and thus for growth in general. Does H have a specific genetic effect different from that of euchromatin? A group of genetic effects (podoptera) was discovered transforming the wing into a leg-like structure. Many different lines were isolated, all comparable but different in genetic and morphological detail. The effect is ubiquitous in *Drosophila*. It is based upon a number of factors located in all chromosomes, which act like multiple factors. The individual factor acts with very low penetrance; combined, the action increases geometrically. It is believed that these factors are mutant conditions of heterochromatic sections for many reasons; the few successful localizations point to heterochromatic regions. Though all the factors have essentially the same effect, they are not interchangeable between the lines and not allelic. But they show a pseudoallelic interaction. The penetrance of podoptera is greatly affected by the Y-chromosome in a very complicated way. Thus, in one line an extra Y in the female reduces penetrance; in another line the females never show podoptera except in the presence of an extra Y. A second Y might act in the opposite direction from a first. Remarkable are the relations to the minutes, most of which act like podoptera. Also, the pleiotropic effects of both are similar. Some other dominants act as pseudoalleles to podoptera. Comparison with other recent work favors the interpretation.

Atmospheric Tides

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The atmosphere exhibits tidal phenomena which can be detected through their effect on atmospheric pressure. The main tidal component is a progressive wave following the sun from east to west, with wave crests near 10 A.M. and 10 P.M., local time. The amplitude of that semidiurnal solar tide reaches 1.3 mb at the equator and vanishes, for obvious reasons, at the poles. The corresponding tide in lunar time has also been found, but its amplitude is only 0.09 mb at the equator. The tidal force exerted by the moon is actually greater than that due to the sun and is known to produce lunar ocean tides stronger than those due to the sun. The unexpected strength of the solar tide relative to the lunar tide in the atmosphere has been interpreted as a manifestation of resonance, and dynamical theories have been developed which seem to show that the atmosphere actually has a period of proper oscillation close to 12 solar hrs. However, in order to produce the observed pressure amplitudes the proper oscillation of the atmosphere should at all times be about 11 hrs and 57 min. Such exact tuning is unlikely in view of the considerable seasonal changes in the temperature of the atmosphere.

The present communication purports to demonstrate that the semidiurnal thermal wave accompanying the gravitational solar tide also must lead to a strengthening of the tide, so that a less exact resonance tuning than the one quoted above can account for the observed tidal amplitude.

Investigation of Meteoric Radio Reflections

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(Introduced by F. E. Terman)

Visual techniques have been used for many years to study meteors. Recently radio reflection methods have enabled quantitative data on meteors and their effects in the upper atmosphere to be obtained at a vastly increased pace.

The experiments being undertaken at Stanford University exploit the Doppler frequency shift imparted to a continuous wave radio signal when it is reflected from a moving surface. As a meteor enters the lower ionosphere, it first forms a rapidly extended line of charge, and the initial radio reflection serves to determine meteoric velocities with an accuracy of better than 4%. Detailed analysis of the early part of the echo also serves to determine the radii of the cylinder on ionization. Seconds later, the fully formed cloud of charge produces reflections from which wind velocities and diffusion coefficients in the 60-mile-altitude region can be deduced.

The meteor echoes are conveniently studied using radio-frequencies of the order of magnitude of 30,000,000 cycles/sec, and typically have a duration of about 1 sec. These short bursts of reflected signal ordinarily occur several times per minute, in contrast to an average visual

rate of meteor detection of 10/hr. The great increase in the number of meteors now available for study makes possible a statistical attack on problems otherwise unapproachable.

Studies Relative to a Temporary Revision of *Neurospora tetrasperma* to an 8-Spored Type

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On certain media the dominant lethal *E* complex in *N. tetrasperma* causes abortion in asci which are heterozygous E/e. On a potato steep medium such asci do not abort, so delimit spores. Instead of 4 large spores, 8 small ones are cut out. Of these, 4 are unisexual, and normal *e* and matings give asci with 4 large spores. The other 4 spores have, as cut out, a single lethal *E* nucleus each. Such spores usually die after germination. A way has been found to induce 17 of these *E* germlings to continue growth to produce strains pure for lethal *E*. These strains, when suitably mated with normal *e* strains, produce again E/e asci with 8 spores. It yet remains to find a way to induce the lethal *E* strains to mate and mature ascocarps with asci and spores. Such asci would be homozygous E/E. This would mean that a temporary reversion from 4-sporedness to 8-sporedness may be made permanent.

The haploid number of chromosomes in both the normal *e* and lethal *E* strains of *N. tetrasperma* is 7. Seven is the haploid number in all races of *N. sitophila* examined. These races include conidial as well as nonconidial, protoperithecial as well as those not producing receptive bodies. Neither the mating type nor the presence or absence of receptive bodies is a matter of a difference in the number of chromosomes.

The Evolutionary Significance of Two Synthetic Allopolyploid Species of *Bromus*

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(Introduced by Ernest B. Babcock)

Hybrids between two perennial species of *Bromus*, section *Ceratochloa*, with 2n = 56 chromosomes, namely, *B. carinatus* and *B. maritimus*, and the annual species of the section *Neobromus*, *B. Trinii*, with 2n = 42, are in both instances vigorous but sterile. Meiosis in these F_1 hybrids is extremely irregular, the 49 chromosomes forming usually 4–6 loosely associated pairs, but otherwise remaining as univalents. In *B. Trinii* × *maritimus* many of the chromosomes become fragmented at meiosis, and their chromatids often reunite to form chromatin bridges at anaphase. Allopolyploids produced by colchicine treatment of these hybrids are mostly from 70 to 85% fertile as to seed set, and in them chromosome pairing is essentially regular, although a few multivalents and univalents are found. At later stages of meiosis many of the chromosomes lag and become extruded from the microspore nuclei. That microspores lacking one or two chromosomes can function is evident from the fact that in third- and fourth-generation derivatives of the original allopolyploids the somatic chromosome numbers recorded for *B. carinatus-Trinii* range from 93 to 98, and for *B. maritimus-Trinii*, from 96 to 100. Plants with deviating chromosome numbers are as vigorous as those with 2n = 98, and no relationship could be found between chromosome number and fertility. Observations of these allopolyploids planted under natural surroundings during the past three years indicates that they will be successful in some sites. The behavior of these new allopolyploid species therefore indicates that both the originating and the establishing of new species can now be carried out under conditions of controlled experimentation. Furthermore, they demonstrate the possibility of combining in a single species chromosome sets derived originally from 7 distinct diploid species, and of increasing successfully the chromosome number found in *Bromus* above that known in any natural species of the genus.

Mechanism of Proteinuria

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The factors concerned in the excretion of protein by the kidney are discussed on the basis of experimental observations. Proteinuria was induced in rats by the parenteral administration of rat serum, of various proteins derived from human and bovine blood, of eggwhite, gelatin, and Bence Jones protein, and of renin. The facts are not explicable on the basis of any simple hypothesis. In addition to all the conditions that influence the formation of urine by the kidney, the results of these experiments indicate that it is necessary to take into account, at least, the size of the protein molecule, the permeability of the glomerular membrane, the reabsorption of protein by the tubule cells from the glomerular filtrate, and the digestion within the tubule cells of the reabsorbed protein. More specific methods than any we now possess are needed for the study of the processes of reabsorption of intracellular digestion of protein by the proximal convoluted tubules.

Sexuality in *Chlamydomonas*

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Plus and minus strains of three heterothallic species of *Chlamydomonas* (*C. minutissima*, *C. intermedia*, and *C. Reinhardi*) were isolated in pure culture. Immobile (palmelloid) cells growing on agar become motile about an hour after flooding with distilled water and function sexually by fusing in pairs if cells from clones of opposite sex are mixed. Motile cells of these species retain their motility and sexuality for more than 24 hrs after transfer to darkness. Immobile palmelloid cultures of them, when flooded in darkness, become motile and sexually functional even after storage in darkness for a week.

When inoculated upon agar containing suitable organic compounds and grown continuously in darkness, *C. Reinhardi* becomes motile but shows no sexuality when flooded with water in darkness. Palmelloid cultures grown in darkness and then illuminated for 12–15 hrs

become motile when taken to the dark room and flooded. The three species were grown in blue light (4,357 A) and in red light (6,150–6,900 A). When taken to the dark room and flooded, both the cultures grown in red and those grown in blue light become motile and sexually functional.

These results are not in accord with what Moewus reports for *C. eugametos* and two species interfertile with it. He finds that motile cells lose their motility and sexuality when tranferred to darkness. Palmelloid cultures of species he studied do not become motile when flooded with water in darkness. He also finds that in red light there is only the formation of the precursor of the sexual substance and that blue light is essential for its complete development. It is thought that in the three species herein reported upon the sexual substance is not the mixture of *cis-* and *trans*-crocetin dimethyl esters, as reported for the *eugametos* group by Moewus.

The Miocene Occurrence of *Sequoia* and Related Conifers in the John Day Basin

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Four genera of the family Taxodiaceae—*Sequoia, Taxodium, Metasequoia,* and *Glyptostrobus*—are represented in the Oligocene and Miocene records of Oregon and adjacent states. All of them are found in rocks of Middle Miocene age in the John Day Basin, within a distance of 60 miles. By contrast, the modern distribution of these trees shows no overlapping ranges: *Sequoia* and *Taxodium* are confined to North America, for the most part on opposite shores; *Metasequoia* and *Glyptostrobus* now live only in Asia, where several hundred miles separate their occurrences in central and in southern China. Their modern habitats differ widely both as to climate and topography.

These genera, together with numerous hardwoods, made their first appearance in the Cretaceous and Eocene floras of Alaska and other northern localities, constituting what is termed the Arcto-Tertiary Flora. In succeeding epochs of the Tertiary period, their ranges were restricted at the north and extended southward; all of them had reached the John Day Basin by Middle Miocene time, involving an interval of about 20,000,000 years. In the ensuing 20,000,000 years they have disappeared from this region as a result of continuing changes in topography and in climate.

Analysis of the past distribution of these conifers, and of their associates both in the fossil record and today, provides a basis for reconstructing many details of their Miocene environments and for explaining their modern distribution.

Mechanism of Immunity in Plague Infections

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Cytological examinations of local subcutaneous depositions of *Pasteurella pestis* in monkeys and mice disclose that in the actively and passively immune animal the bacilli are fixed at the site of injection and multiplication is always less than in the control, nonimmune animals. The factors which affect the multiplication are extracellular and intracellular. Definite agglutination and morphologic changes demonstrable by phase-contrast microscopy affect the majority of the extracellular bacilli during the early phases of the infection in the immune. With the arrival of polymorphonuclear leucocytes, intensive phagocytosis participates in the removal and destruction of the bacilli. In the cytoplasm of the cells of immune hosts the bacterial elements stain faintly. Moderate but definite phagocytosis characterizes the behavior of the leucocytes in the normal animal. *In vitro,* the serum of plasma without cells obtained from actively or passively immune animals definitely suppresses the growth and reduces the number of viable bacilli during the first 12 hrs; in fact, 0.3 ml of serum may sterilize an inoculum of 50 bacilli. The bactericidal action of the serum is apparently selective, as evidenced by the rapid multiplication of a few surviving bacilli after the 12th hr. Bacteriostatic and bactericidal action of whole blood is more marked than that of serum alone. Opsonocytophagic tests indicate that avirulent plague bacilli are more readily phagocytized by polymorphonuclear leucocytes and macrophages than are virulent organisms. A highly efficient phagocytic activity by the macrophage system of the lungs in part explains the striking quantitative reduction of the number of viable bacilli within 12 hrs after exposure of guinea pigs to infective clouds of *Pasteurella pestis.* The mechanism of resistance in plague is dependent on an interplay of antibodies and phagocytic cells which is significantly enhanced in the actively immune animal.

Differences in Physiological Activity of Plant-Growth Substances

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The growth hormone of plants takes part in a far greater number of reactions and processes than was originally expected. It causes cell elongation, root formation, lateral bud inhibition, and parthenocarpic development of fruits, prevents abscission of leaves and fruits, etc. A number of substances, all possessing the same basic molecular configuration, are active in these processes. Structurally closely related substances like 2,4-D are used on a large scale as weed killers. To explain this multiplicity of responses and to understand the differences in quantitative response between plants, it becomes necessary to differentiate between physical and chemical properties of these substances. It has been shown that the difference in the rate of translocation through tissues or the permeability of a substance into cells of different plants may explain apparent differences in activity.

Both indole acetic acid and 2,4-D elicit the same basic response in the pea test. In higher concentrations they exert a purely additive effect when mixed. However, when they are mixed in such low concentrations that neither of them is very effective any more, the resultant

response is more than twice that which could be expected from a purely additive effect. This can be explained on the basis that at these low concentrations indole acetic acid and 2,4-D actually participate in two different reactions which supplement each other. At higher concentrations either of these two substances can provoke both reactions. Further evidence of the correctness of this interpretation can be given by the use of hemiauxins, which at any concentration can provoke only one of these two reactions.

The Perception of Speech and Its Relation to Telephony

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This paper describes a method of calculating the number of correctly understood fundamental speech sounds, syllables, words, or sentences when talkers and listeners use a telephone system. The quantities that enter into the calculation are the physical characteristics of the telephone system, the noise conditions at the listener's ear and the proficiency of the talkers and the listeners.

The fraction of such speech sounds which are correctly understood is designated the articulation. A quantity called the articulation index, A, is calculated directly from the physical characteristics and noise conditions. It is related to the sound articulation, s, and the proficiency, p, of the talker-listener combination by the formula:

$$A = -\frac{.53}{p} \log_{10} (1 - s).$$

The value of A is the product of four factors: the frequency response factor, F; the volume factor, V; the ear-desensitizing factor, E; and the special distortion factor, H.

The first factor, F, is dependent upon the shape of the response *vs.* frequency characteristic for the telephone system. V depends upon the effective gain in the system compared to the masking level of the noise. E depends upon the maximum response. It becomes less than unity for high gains, because the loud sounds cripple the ear response mechanism so that the listener cannot make such fine discriminations as when loud sounds are absent.

The fourth factor, H, is unity except for special types of distortion. A method of calculating H is given for the following types of distortion: pure tone interference, loud noise interference, nonlinear distortion, frequency shift, frequency multiplication, carbon microphone distortion, and distortion due to caller or listener or both being in reverberant rooms.

A comparison of calculated and observed results is shown for about 150 systems for which the articulation data and the physical characteristics and noise conditions were known. The data for systems which were taken in the Bell Telephone Laboratories correspond to three different periods, namely, 1919–25, 1929–32, and 1935–37. Different groups using different testing lists of syllables and different techniques were employed in each of these periods. A fourth set of data, obtained at Harvard University during the war, emphasized the effects of high levels of noise, and a fourth set of lists and techniques was used.

A method is given for correlating the results of these various tests and for obtaining each kind of articulation from the calculated values of A for each system. These systems include high-pass, low-pass, and band-pass filter systems; various types of resonant systems, from those having a very broad response to those having very narrow peaks; and systems using carbon microphones of various types which have been used in commercial telephone systems at different times during the past 30 years. The types of interfering noises used range from pure tones having various frequencies throughout the speech range to that encountered in an average room and to very intense noise such as is encountered in airplanes or tanks.

It will be seen that the methods outlined give results which are in good agreement with the observed data for this great variety of systems.

On Univalent Analytic Functions

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and

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(Introduced by S. Lefschetz)

If $f(z) = z + a_2z^2 + \ldots$ is regular and univalent in $|z|$, < 1, we say it belongs to class S. The coefficients a_2, a_3, $\ldots$ a_n determine a point in $(2n-2)$-dimensional real Euclidean space whose coordinates are the real and imaginary parts of these coefficients. The set of these points when $f(z)$ varies over all functions of class S is a region, V_n, topologically equivalent to the closed $(2n-2)$-dimensional full sphere. The functions of class S which correspond to points of the boundary of V_n satisfy a quadratic second-order differential equation depending on $2n-3$ real parameters. Conversely, if a function is regular in $|z| < 1$ and satisfies one of the equations, it belongs to S and corresponds to a point in the boundary of V_n. Special properties of these functions are obtained. Functions which belong to supporting points of V_n are shown to have special properties.

Singularities of Analytic Functions at the Confluence of Two Boundary Conditions

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(Introduced by Griffith C. Evans)

The following problem is discussed:

In a neighborhood of the origin of the x,y-plane, let $\varphi(x,y)$ be continuous for $y \leqq 0$ and harmonic for $y \leqq 0$ with the possible exception of the origin; furthermore, suppose $\frac{\partial\varphi}{\partial y} - \varphi = 0$ for $y = 0$, $x > 0$, and $\frac{\partial\varphi}{\partial y} = 0$ for $y = 0$, $x < 0$. What is the nature of the singularity of the origin for $\varphi(x,y)$, resp. for the analytic function $\chi(z)$ of $z = x + iy$, whose real part is $\varphi(x,y)$ and whose im-

aginary part vanishes at (0,0)? Since the boundary condition permits the analytic extension of $\chi(z)$ by reflection on the negative x-axis, one obtains on the positive x-axis a second analytic function designated by $\chi(z)$, as analytic continuation of $\chi(z)$, satisfying the relation

$$(R)\chi'(z) - \chi'(z^-) + i\left(\chi(z) + \chi(z^-)\right) = 0.$$

If used for arbitrary z, (R) permits the analytic extension of $\chi(z)$ into the whole Riemann surface of log z, with $\lim_{z \to 0} \chi(z) = \varphi(0,0)$.

The determination of the singularity of $\chi(z)$ at the origin is of importance in hydrodynamics for the behavior of surface waves near a surface obstacle.

A Functional Analysis of Regional Differences in the Human Fovea

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Under suitable conditions of illumination the central portion of the yellow spot of the retina may be seen moderately well outlined in the visual field. This phenomenon has been independently discovered many times. Maxwell is credited with the first painstaking investigation of it; Helmholtz devoted attention to it; Gullstrand, Dimmer, and others, chiefly German scientists, have studied it. The present paper outlines a standard routine for making such examinations of the central retina and reports some research on it.

The yellow pigment of the macular region absorbs blue light but does not appreciably absorb red. The optimal filter is therefore a purple dichroic passing deep violet-blue and deep red. Such a filter (Roscoe No. 28) is mounted directly at the side of a neutral filter (Wrattan No. 96) with similar over-all density. The filters are used before the eye alternately while the subject looks at the screen of an X-ray viewing box, on the face of which the outlines of the observed fields are plotted. Results are reported for 20 men, age 19–32. The average diameter of the projected entoptic image equals $2\frac{1}{2}°$ of visual angle. The spot is characteristically made up of three zones, two concentric rings and a central disc, the latter averaging 33 minutes in diameter and designated as Area 4. The ring immediately surrounding the disc is designated Area 3, the outside ring as Area 2, and the surrounding visual field as Area 1. Areas 2 and 4 show the same color characteristics, usually reported as purple or some variation, such as red-purple, magenta, etc. Areas 1 and 3 lack this purple character and are usually reported as neutral, exhibiting just brightness. This is the result when looking through the dichroic filter. On shifting to the neutral filter, Areas 2 and 4 appear bright green, as should be expected according to the after-image law; Areas 1 and 3 are again neutral. Individual differences are, of course, observable, both in size and in regularity of regional pattern. The theoretical implications of these and earlier findings are discussed. Research growing out of this foveal analysis is briefly discussed, and this form of examination is recommended as a useful approach in correlating functional and structural studies of the fovea, which is one of man's most prized psychophysical possessions.

The n-Ality Theory of Rings

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(Introduced by G. C. Evans)

The classic duality theory which is exhibited by Boolian rings (and algebras) is actually a phenomenon (dormantly) inherent in all rings; this *ring duality* theory has been presented and variously developed in a series of previous communications.

It is now shown that this ring duality may itself be oriented within the framework of a unified *general transformation-invariant theory*, in which all concepts of given ring—in fact, more generally, of any kind of operational discipline—are transformed "cogrediently" (or else "contragrediently") with each of an admissible group, K, of "coordinate transformations" in the ring (or discipline), in a manner similar to the traditional cases (which are subsumed in the general theory), e.g. tensors, matrices, groups, configurations, etc., in different coordinates. This leads to the K-ality theory of the discipline. The original (*simple*) duality theory of rings corresponds to a certain special choice of K, of order 2.

In exploring the general K-level an interesting new class of p-ring-logies is exhibited, a generalization of the Boolian case (corresponding to $p = 2$). The *p-ality* theory of these rings is explicitly given. It is shown, in particular, that the 3-ring-logics ($p = 3$) embrace the *3-valued logic*, which consequently, as all p-rings, possesses an intrinsic *tri-ality* theory. Thus, the familiar ladder ($p = 2$): 2-valued logic (= logic of propositions) $\subset$ Boolian-rings $\longleftrightarrow$ Boolian-algebras, with encompassing (simple) duality theory, is elevated a step to ($p = 3$): 3-valued logic $\subset$ 3-rings $\longleftrightarrow$ 3-algebras, with enveloping tri-ality theory. This leads to a rich comparative study.