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Ferredoxin and Photosynthetic Phosphorylation

Recent investigations of energy conversion reactions of photosynthesis have revealed the key role of ferredoxin, an iron-containing protein native to photosynthetic cells [*Science* **149**, 1460 (1965)].

In isolated chloroplasts, two photochemical reactions linked with ferredoxin, cyclic and noncyclic photophosphorylation, convert radiant energy into chemical energy. Cyclic photophosphorylation yields only adenosine triphosphate (ATP), whereas noncyclic photophosphorylation yields, in addition to ATP, molecular oxygen and reduced ferredoxin. The oxygen is set free, and the reduced ferredoxin serves as an electron donor for the reduction of triphosphopyridine nucleotide (TPN) by an enzymic reaction that is independent of light. Thus, aside from the evolution of oxygen, the photoreduction of ferredoxin is linked to the generation of ATP and $TPNH_2$ that are required for the biosynthesis of organic compounds from CO_2.

Cyclic photophosphorylation catalyzed by ferredoxin was studied earlier mainly in monochromatic light that gave low rates of ATP formation. By illuminating spinach chloroplasts with a wide spectral band of light, we have now obtained rates of ferredoxin-catalyzed cyclic photophosphorylation that are up to 34 times higher than those in monochromatic light and are comparable with maximum rates of photosynthesis of land plants. The highly active cyclic and noncyclic photophosphorylations give contrasting responses to several chemical inhibitors. Moreover, cyclic and noncyclic photophosphorylation differ strikingly in their response to red and far-red light. Noncyclic photophosphorylation shows a "red drop," that is, its rate declines at longer wavelengths of red light and stops almost completely at 714 mμ. By contrast, cyclic photophosphorylation shows a "red rise," that is, its rate increases sharply with an increase in wavelength to 714 mμ.

Ferredoxin-dependent cyclic and noncyclic photophosphorylation jointly account for the main products of the photochemical phase of photosynthesis in vivo. Other substances such as ferricyanide, menadione, flavin mononucleotide (FMN), and phenazine methosulfate that are also effective in photophosphorylations by chloroplasts in vitro act as substitutes for ferredoxin.

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Bioelectric Properties of Boergesenia forbesii

This tropical green alga, formerly known as *Valonia forbesii*, has been assigned by Feldmann to a new, Indo-Pacific genus. Its vacuolar sap is an almost pure KCl solution, 0.65 to 0.7*M*. Its bioelectric properties are on the whole like those of *Valonia*, but it displays a larger potential and is more sensitive to various experimental changes.

When first measured, there is often a small potential difference across the protoplasm, the vacuole being negative to the sea water. But this soon reverses, and the potential reaches 20 to 40 millivolts (mv), the vacuole now being *positive*, and remaining so for many days. Its value can be increased to 50 or 60 mv by doubling the concentration of KCl (to 0.025*M*) in the sea water, or decreased to 10 to 15 mv by halving the K to 0.006*M*. Still lower K concentrations often reverse the potential, and in potassium-free sea water (artificial), the value may reach 50 mv (vacuole negative). Potassium ion evidently has a high mobility in the protoplasmic surface (as confirmed by radiopotassium penetration into the cell).

On the contrary, large changes in the sodium content of the sea water are almost without effect—even to the complete substitution of choline chloride for NaCl. Substitutions of other anions for Cl are also almost ineffective (unlike *Halicystis*). Radiosodium scarcely penetrates the cells at all.

Light has a large effect upon the normal potential, often increasing it by 10 or 15 mv. This effect is enhanced by low O_2 or high CO_2. Conversely, potentials reversed by low K are rendered still more negative in the light; values as high as 90 mv (inside negative) have been observed by illuminating in K-free sea water.

Light lowers the electrical resistance across the protoplasm. Attempts to measure the potential across the plasma membrane alone (in aplanospores) have so far been unsuccessful.

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DNA Homologies among Temperate Coliphages

The well-established genetics of temperate coliphages make them an ideal system in which to study evolutionary relationships. The coliphage system also provides an opportunity to isolate specific DNA regions through appropriate phage DNA agar hybridizations.

Lambda, 434, and ϕ80 phages show high percentages of relatedness (20 percent between ϕ80 and λ to at least 50 percent relatedness between 434 and λ). To study the qualitative aspects of phage DNA duplexes, we examined the thermal stability of the hybridized DNA by eluting in a series of washes at increasing temperatures. Under these conditions the thermal stabilities of

heterologous duplexes appear to be virtually identical to those of homologous duplexes. This observation apparently reflects extensive conservation of the related segments of temperate coliphage DNA's.

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Repeated Nucleotide Sequences of DNA

Many thousands of copies of relatively short nucleotide sequences are present in the DNA of higher organisms. These repeated sequences make up a majority of the DNA of most living forms higher than bacteria. Families of repeated sequences apparently result from a balance between the excessive duplication of particular sequences and events of mutation, deletion, and translocation. They are created and lost with a half period of the order of 100 million years.

The members of different families of repeated sequences are interspersed with each other in the long double-stranded DNA molecule(s). The number of members of families of recognizably related nucleotide sequences within the DNA of an individual organism ranges from hundreds to millions. Again, within the DNA of an individual, some families are comprised of a set of nearly identical copies of a sequence, while other families are made up of sequences which have diverged from each other. The degree of dissimilarity of the sequences can be taken as an index of the age of a family.

This internal order in the DNA was measured as follows: Purified DNA was sheared into small fragments (to separate interspersed short sequences); the complementary strands were dissociated, and the kinetics of reformation of complementary pairs were measured in several ways (to assess the concentration of similar sequences and thus the degree of repetition); and the thermal stability and hyperchromicity of the resulting pairs were compared to native DNA to estimate the accuracy of fit and amount of helical structure and thus the degree of similarity of the repetition.

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Cooperative Interaction in Hemoproteins and Dehydrogenases

The kinetics and equilibria of ligand binding to crystalline hemoproteins and dehydrogenases reveal four cases of cooperative interaction. (i) The $T \rightarrow R$ allosteric interconversion [Kirschner *et al., Proc. Nat. Acad. Sci. U.S.* **56**, 1662 (1966)] in the reaction of yeast phosphoglyceraldehyde dehydrogenase with diphosphopyridine nucleotide (DPN) is readily observed in the crystalline, amorphous, and soluble protein. (ii) The reaction of crystalline horse ferrihemoglobin with azide shows a high degree of biphasicity [Chance and Ravilly, *J. Mol. Biol.* **21**, 195 (1966)]. (iii) and (iv) Crystalline lamprey and sheep hemoglobins reduced by dithionite show sigmoid titration curves in their reaction with CO, with n values of over 2, as determined by direct spectrophotometric titrations and gasometric assays. In case (iii), the unit cell dimensions and space group are unaltered in the reaction [Greer *et al., J. Mol. Biol.* **18**, 547 (1966); Love *et al., Rev. Sci. Instrum.* **36**, 1655 (1965)].

In cases 1 and 4, the small, robust crystals employed retain crystallinity and dichroism, and possibly the lattice forces prevent quaternary structural changes in the short interval required for the reaction [Perutz, *Acta Crystallogr.* **6**, 859 (1953)]. Thus in three and perhaps all four cases, only secondary and tertiary structural changes may be involved. This leads us to a hypothesis to explain these cooperative interactions. Extensive structural changes involving regions of the protein removed from the ligand binding site accompany the conversion of ferrimyoglobin to the lower spin cyanide and hydroxide derivatives [Watson and Chance, in *Hemes and Hemoproteins* (Academic Press, New York, 1966), p. 149] and, by analogy, in the CO reaction as well. Such remote changes may serve to transfer ligand binding information through molecular contacts in the crystalline state or through subunit contacts in a polymeric protein. Control of reactivity through such contacts is already suggested by our observations of the great decreases of reaction rates in crystalline proteins.

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Dependence of the Early Receptor Potential on the Orientation of Rhodopsin

The early receptor potential (ERP) is an electrical response of visual receptors that arises with no detectable latency following intense flash illumination of the eye. Recent evidence suggests that the ERP is generated by charge displacements in rhodopsin molecules [R. A. Cone, *Science* **155**, 1128 (1967)]. Apparently, these charge displacements can be observed directly because an intense flash simultaneously excites a large number of rhodopsin molecules, and all the molecules are highly oriented in the lamellar membrane structure of the receptor outer segments. Previous work has shown that if an excised eye is heated to 58°C and then cooled, the ERP is irreversibly abolished, though all the rhodopsin remains. We have been investigating the possibility that this thermal decay of the ERP is caused by the loss of orientation of the rhodopsin.

In a parallel series of experiments on the eye of the albino rat, pairs of eyes were excised, heated for 10 minutes at various temperatures, and then cooled to room temperature. To measure the maximum amplitude of the ERP, one eye of each pair was exposed to an intense flash. To determine the degree of orientation of the rhodopsin, the retina of the other eye was examined spectrophotometrically with previously described techniques [G. Wald, P. K. Brown, I. R. Gibbons, *J. Opt. Soc. Amer.* **53**, 20 (1963)]. We find that for temperatures below 48°C neither the ERP nor the pigment orientation are affected by the heat treatment. But above this temperature the amplitude of the ERP decreases, and the pigment starts to disorient. By 58°C, the ERP is essentially abolished, and the rhodopsin appears completely disoriented, as though in solution. Thus the amplitude of the ERP appears to fall exactly in parallel with the loss in orientation of rhodopsin.

RICHARD A. CONE, PAUL K. BROWN
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Genetic Relationships among Viruses and Bacteria

A sizable portion of the DNA of lysogenic (or semilysogenic) viruses has been shown to be homologous to the DNA of their bacterial hosts. Genetic relationships among five viral-host systems (λ phage/*Escherichia coli*, φ80 phage/*E. coli*, 15(TAU)⁻phage/*E. coli*, P22 phage/*Salmonella*, and T3 phage/*E. coli*) have been studied with the use of an extension of the DNA-agar method of Bolton and McCarthy [*Proc. Nat. Acad. Sci. U.S.* **48**, 1390 (1962)].

The results show that: (i) genetic similarities involving a third to approximately a tenth of the viral genomes are present; (ii) these homologies are contained in numerous segments throughout the viral DNA's; (iii) DNA homologies exist among all of the bacteriophages as well as with their respective bacterial host; and (iv) the many regions of DNA homology among the viruses and between the viruses and the bacteria indicate the large number of different genetic events that have occurred during evolution. The lysogenic process in providing a means of viral survival is obviously a mechanism for the introduction of new genetic elements into both bacterial and progeny viral DNA. Furthermore, the results suggest that in lysogenic systems viral survival is dependent on the conservation of certain essential genetic elements, characteristic of both viral and bacterial DNA.

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Infectious Hybrid Sterility in Drosophila

The Santa Marta and Mesitas strains of the superspecies *Drosophila paulistorum* produce sterile male hybrids when Santa Marta is used as the female parent. This sterility seems to be due to the interaction of the Santa Marta cytoplasm with the Mesitas Y chromosome. However, after seven generations of backcrosses to Mesitas, the cytoplasmic difference is overcome by Mesitas genes. As shown by Williamson and Ehrman, Mesitas females injected with homogenates of F_1 hybrids or of Santa Marta males, and crossed to Mesitas males, produce sterile hybrid sons.

Heat shock (31°C for 24 hours) applied either to female parents, or to the eggs which produce these parents, reduces the number of sterile hybrid males in a series of seven backcross generations. It is hypothesized that this heat shock depresses the growth, and therefore the effects, of a cytoplasmic factor, which is suspected of causing the maternally transmitted hybrid male sterility.

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Solar Influences on the Cosmic-Ray Diurnal Variation

Statistical analyses of the cosmic-ray intensity data from ionization chambers at Cheltenham-Fredericksburg (U.S.), Christchurch (New Zealand), and Huancayo (Peru) establish an excellent agreement between the variability of the diurnal variation at these three stations over the interval 1937 to 1965, averaged over practically three solar cycles. The magnitude of the diurnal component, P, in the asymptotic direction of 18 hours solar time is similar to the corresponding average for each of two measures of magnetic activity and indicates that in the complete absence of magnetic activity this component would practically vanish. This result appears compatible with the corotation theory of Parker and others which accounts for the average P component of the diurnal anisotropy. The magnitude of the component, N, of the diurnal anisotropy in the asymptotic direction of 12 hours solar time exhibits an as yet unexplained but well-determined wave with a period of two solar cycles and with amplitude half that for the P component. This wave passes through zero near 1958 when Babcock's solar magnetic-field measurements indicated a reversal in the direction of the sun's general magnetic field.

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Association of 1-1 Salts in Water

Association of ions to nonconducting pairs is a familiar characteristic of electrolytic solutions in solvents of dielectric constant lower than about 30, but has not been reported for 1-1 electrolytes in water, although theoretically the association constant for pair formation can never be zero. The estimated association constants in water are of the order of unity. The corresponding concentration of pairs in the range of total concentrations amenable to analysis by available theory (up to about $0.01N$) is too small to be detected even by conductance measurements of high precision. We have found that the following semiempirical equation precisely reproduces experimental observations for a number of alkali halides in water up to about $0.1N$

$$\Lambda = \Lambda_o - S\,c^{1/2} + E\,c\log c + A\,c + B\,c^{3/2}$$

where Λ is equivalent conductance, c is concentration, Λ_0 is limiting conductance at zero concentration, S and E are theoretically predictable constants, and A and B are empirical. This result suggested reinvestigation of the theory; reintegration of the equations used by Fuoss and Onsager, this time with retention of terms of order $c^{3/2}$, and use of the mass action equation to relate concentrations of free and paired ions led to an equation of the form

$$\Lambda = \gamma\,(\Lambda_o - \Delta\Lambda)\,(1 - \Delta X/X)$$

where γ is the fraction of unpaired ions, $\Delta\Lambda$ is the electrophoretic term, and ΔX is the relaxation field. The functions are quite complicated but can be handled by an electronic computer. Data for lithium, sodium, and potassium chlorides and for cesium bromide in water up to $0.1N$ conform to the equation within the experimental error (0.01 to 0.02 percent) and yield association constants of the expected order of magnitude. Furthermore, these constants agree with the values obtained by extrapolation of the constants for systems of low dielectric constant.

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Polygenic Theory of Schizophrenia

The etiology of schizophrenia is unknown, but strong views exist about the significance of the role to be accorded genetic factors ranging from minimal to sufficient. Proponents of a genetic etiology have usually talked in terms of Mendelian genetics. Classical

segregation ratios are not found for the relatives of schizophrenics. One of the possibilities not given sufficient attention involves positing a large proportion of cases as being polygenically determined. Thus the disorder would be treated like a threshold character (Gruneberg) whose phenotypic appearance would depend on both the number of genes present and the amount of stress. The model would predict the continual appearance of segregants in the offspring of normal parents (Lerner's phenodeviants), increased rates of schizophrenia in high-risk families, and a slow response to negative selection. Schizophrenics could be thought of as part of the genetic load, the price paid for conserving genetic diversity.

Falconer has now provided techniques for estimating the heritability of the liability to human diseases that appear to have an all-or-none manifestation but are in fact determined by an underlying graduation of some attribute really causal. Essentially the method converts incidences into regression coefficients and the latter into estimates of the heritability of liability. Heritability was substantial (greater than 60 percent) when estimated independently from identical or fraternal twins, siblings, parents, and aunts and uncles. Similar results were obtained for data from the relatives of diabetics. A valid polygenic model permits the conclusion that relatively low incidences of schizophrenia (for example, 5 percent) in the parents or siblings of probands is compatible with a high degree of genetic control.

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Regulation of Porphyrin and Heme Biosynthesis: A New Control Function of Steroids

Certain C-19 and C-21 steroids of the 5β-H (A:B *cis*) configuration, previously considered physiologically inert hormonal degradation products, have been shown to function in control mechanisms for heme biosynthesis. Active metabolites include etiocholanolone, pregnanolone, and pregnandiol. These steroids stimulate chick embryo liver cells in culture to make more porphyrins, and chick blastoderm erythroid cells to make more hemoglobin. They act, like certain drugs in the liver, to induce formation *de novo* of the enzyme, δ-aminolevulinic acid synthetase (ALAS), which controls the limiting step in heme biosynthesis. Thus, an increase in ALAS will result in an increase in intermediate porphyrins in the synthetic sequence (detectable in liver cells by fluorescence), as well as in heme, the end product. In addition, various hemoproteins such as hemoglobin and cytochromes might be expected to be controlled by heme formation.

A repressor-operator mechanism is postulated to explain steroid-induction of ALAS. The repressor would comprise an aporepressor protein and a corepressor heme. Steroids would act to displace heme from its binding site, thus inactivating the repressor. The code for the structural gene of ALAS would then be transcribed, and more ALAS formed.

In liver, ALAS is induced not only by active steroids, but by drugs such as the barbiturates, by the same mechanism. In hepatic porphyria, a hereditary disease, steroids and drugs act similarly to evoke a marked increase in heme precursors, and clinical and chemical exacerbation of the disorder.

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Roles of Intellectual Abilities in the Learning of Concepts

The major objective of this study was to determine whether certain abilities in the structure of intellect (SI) could be shown to be relevant in the learning of class ideas or conceptions.

Each learning task required the effort to learn to recognize the class membership of exemplars of each of four classes, when different exemplars of those classes were presented in random sequence in 96 5-second trials, with feedback information concerning the correct class given immediately after each trial. The three learning tasks involved visual-figural, symbolic, and semantic information, respectively, each with four concepts to be discovered.

The 175 high-school students had been administered a battery of tests representing 15 SI abilities, of which 11 deal with classes by way of cognition, memory, divergent production, and convergent production. A factor analysis was conducted to verify that the 43 tests measured status in their respective SI abilities.

To determine the possible systematic roles that certain abilities played in learning, stage scores (numbers of correct identifications of concepts for each of 12 sets of successive trials during learning) and also two overall learning scores (naming concepts and trials to mastery, respectively) were determined for each subject. These learning-score variables were extended into the test-factor space, thus determining factor loadings for the learning scores with respect to the intellectual abilities.

Within the limitations that the results must show correlation between learning score and the vector representing the ability in order to show relevance of a certain ability, some conclusions could be drawn with respect to the relative importance of the abilities investigated. Furthermore, certain trends were noted in factor loadings in relation to stage scores, indicating that some abilities are relatively more important at different stages of each learning event.

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Chromosomal Organization in Pseudomonas putida: Transduction with Lytic Bacteriophage

Our recent demonstration of generalized transduction with lytic phages Pf16 and Pf16hl (Chakrabarty *et al.*, *Bacteriol. Proc.*, in press) has permitted an extension of our earlier finding of a separate regulation of early and late enzymes in the tryptophan biosynthetic pathway [Crawford and Gunsalus, *Proc. Nat. Acad. Sci. U.S.* **56**, 717 (1966)] with mapping of the responsible loci.

In *Pseudomonas putida*, strain Cl, the enzymes from chorismate to tryptophan require six structural genes which map in three linkage groups that contain (i) loci for anthranilate synthetase (AS), phosphoribosyl transferase (PRT), and indoleglycerolphosphate synthetase (InGPS); (ii) the phosphoribosyl anthranilate isomerase (PRAI) locus unlinked to other tryptophan loci, but with 70 percent linkage to a methionine locus, *met*-1; and (iii) the loci for the A and B subunits of tryptophan synthetase. The first operon is controlled by end-product repression, and the third by substrate

induction with constitutivity closely linked.

Fargie and Holloway [*Genet. Res.* **6**, 284 (1965)] with *P. aeruginosa* reported the absence of clustering in genes for biosynthetic pathways, but observed linkages of loci for *met* and PRAI, and unilaterally between two classes of tryptophan synthetase mutants which we attribute to cross-feeding between transductants and recipients. A related chromosomal organization in these two species is suggested.

These transductants remain sensitive to homologous phage; therefore reinfection is avoided by using phage at low multiplicity after UV inactivation and plating with antiphage serum. Single marker transfers as high as one per 3×10^5 original plaque-forming phage is observed.

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Quantitative Study of Pain and Its Reduction through Hypnotic Suggestion

If pain is induced by immersing a subject's hand and forearm in circulating ice water, the pain mounts very rapidly. When a scale of 0 to 10 is used, with 10 representing a pain so great that the subject feels he can no longer keep his hand in the water, a straight-line function emerges when the logarithm of the pain-state report is plotted against the logarithm of time. This is, of course, the power function found commonly for other sensory processes by S. S. Stevens. The results are orderly and reproducible, and reflect persistent individual differences in responsiveness to painful stimulation.

When subjects undergo hypnotic induction and the suggestion of analgesia is given, the subjective reports of pain produced by the ice water are reduced by an amount corresponding to the independently measured susceptibility to hypnosis, the most highly susceptible subjects blocking out the pain completely.

In keeping with the findings of others, the physiological accompaniments of the ice-water stimulation (plethysmographic constriction in the opposite hand, increased heart rate, increased breathing rate) are little affected by hypnosis despite the great subjective changes. The lack of physiological change does not negate the reduction of pain through hypnosis, but indicates that the locus of the effect must be in the higher neural centers concerned with attention and alterations in consciousness.

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Estimation of the Limits of Heritability of Traits by Comparison of Monozygotic and Dizygotic Twins

The heritability (h^2) of a trait is the proportion of phenotypic variance (σ_P^2) attributable to genotypic variance (σ_G^2); that is, $h^2 = \sigma_G^2/\sigma_P^2$. Most heritability studies of human traits have used comparisons of intraclass correlations (r) of monozygotic (MZ) and dizygotic (DZ) twins of the same sex reared together to obtain estimates of heritability. The prevailing method of expressing heritability quantitatively has been in terms of Holzinger's H index [*J. Educ. Psychol.* **20**, 241 (1929)] : $H = (r_{MZ}\text{-}r_{DZ})/(1\text{-}r_{DZ})$. However, it can be shown both mathematically and empirically that Holzinger's H index is not an estimate of heritability and is not even a monotonic function of heritability, defined as h^2. Previous attempts [R. C. Nichols, *NMSC Research Rep. 2*, No. 8 (1966); S. G. Vandenberg, *Psychol. Bull.* **66**, 327 (1966)] to improve the H index have resulted in other indices which also fail to estimate h^2. Yet they are often wrongly interpreted as if they were h^2. A new formula is proposed for estimating heritability from data on twins. It yields the maximum information that can be obtained from a comparison of r_{MZ} and r_{DZ} (corrected for attenuation); it is a true estimate of h^2 within the limits of sampling error; and it permits estimation of the upper and lower bounds of heritability for a given set of data by considering empirical estimates or theoretical assumptions concerning the expected range of genetic correlations (ρ_G) between siblings (or DZ twins) due to assortative mating. The equations are:

$$h^2 = (r_{MZ} - r_{DZ})/(1 - \rho_G)$$
$$E^2 = (r_{DZ} - \rho_G r_{MZ})/(1 - \rho_G)$$
$$e^2 = (1 - h^2 - E^2) = 1 - r_{MZ}$$

where h^2 is the proportion of the trait variance due to heredity, E^2 is the proportion due to systematic (between families) environmental influences, and e^2 is the proportion of variance due to unsystematic or random (within families) environmental effects. For traits in the abilities domain, the values of ρ_G to be entered into the above formulas for estimating the extreme limits of h^2 are 0.50 (that is, the mean correlation between siblings with random mating of parents) and 0.66 (that is, the theoretical mean correlation between siblings if the mother were self-mated or the parents were MZ twins). Applications of these formulas to twin data on mental abilities, scholastic achievement, personality traits, and physical characteristics are presented for comparison with Holzinger's H index and other unsatisfactory methods of estimating heritability. Ways are suggested for interpreting the results arrived at by the proposed formulas in terms that are readily comprehensible and unambiguous to nonspecialists.

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Racial Differences in Intelligence: Still an Open Question?

After 50 years of intensive investigation, thousands of empirical studies, several major theories, and a major controversy which ripped asunder the tranquility of the testing movement, the question remains essentially unanswered: Are there real differences to be found between races on the variable of intelligence? If not, why is it that this variable is immune, when so many others seem free to vary? No one would question that one race is taller, on the average, than another, or darker, or has different bone structure, or can even jump higher, but it seems impossible to get a rational answer to the question of variance of intelligence.

The present paper will examine the major issues briefly and identify the major obstacles which have prevented definitive answering of the question. It will discuss (i) the genetic or fixed intelligence root (referring to the work of Darwin on natural selection, Galton on hereditary genius, Goddard on the Kallikak family, Terman and Honzik on IQ constancy, Thurston and Spearman on test intercorrelations, Newman, Freeman, and Holzinger on the intelligence of twins, and Garrett on racial differences); and (ii) the learned or en-

vironmental intelligence root (with reference to the work of Newman, Freeman, and Holzinger on identical twins reared apart, Anderson on variance of test-retest IQ, Schmidt and Wellman on the effect of nursery school training, Gray, Blatt, and Deutsch on cultural deprivation, Miller and Dregger on confounding of social, economic, educational, and racial variables, and Kennedy, Van De Riet and White on normative data on 1800 southeastern Negro elementary school children).

Delay in investigation has been caused by (i) research on group differences contrary to current national emotional climate; (ii) fear of misuse of data; (iii) ethical problems concerned with definitive research and lack of control of variables; and (iv) difficulty in definition of race, and confounding of race, social class, and opportunity. A definitive study should deal with reasonable numbers over a 20-year span. Experimental children should be reached at birth and placed in adequate middle-class homes. Such children could well be illegitimate children from all strata of socioeconomic level. They should obtain all school advantages of middle-class environment. There should be two control groups—Negro and similar socioeconomic white.

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Protein Flexibility in Enzyme Action and Enzyme Control

Conformational changes during enzyme action apparently play a major role in the control of enzyme activity. These changes can explain specificity properties, regulatory behavior caused by the activation or inhibition of the enzymes by molecules other than the substrates, and cooperative effects caused by the interaction of protein subunits. A model based on the flexibility properties of the protein which can explain these effects has been developed. It assumes that the primary conformational effect of the ligand (substrate, activator, or inhibitor) is on the protein site to which it is bound. A conformational change at this site can in turn affect the conformational stability of neighboring sites, the extent of the effect being dependent on the strength of interaction between subsites. Very strong interactions result in Hill coefficients which closely approximate the number of subsites. Weak interactions result in Hill coefficients of 1, that is, Michaelis-Menten behavior. When the strength of the interaction of adjacent subunits is designated by appropriate constants K_{AB}, K_{BB}, and so forth, the observed behavior of many regulatory enzymes can be explained qualitatively and quantitatively.

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Crystallization of Acetylcholinesterase

According to theory, acetylcholine (ACh), reacting with its receptor protein, induces a conformational change and thereby initiates the sequence of events effecting the increased ion permeability of excitable membranes in nerve and muscle fibers during electrical activity [D. Nachmansohn, *Chemical and Molecular Basis of Nerve Activity* (Academic Press, New York, 1959), p. 235; ———, *Ann. N.Y. Acad. Sci.* **137**, 877 (1966)]. The enzyme AChesterase rapidly hydrolyzes ACh, thereby restoring the barrier. This enzyme was first extracted from electric organ of *Torpedo* [D. Nachmansohn and F. Lederer, *Bull. Soc. Chim. Biol.* **21**, 797 (1939)]. This tissue is highly specialized for bioelectrogenesis and a suitable source of enzyme: it contains only 30 g of protein per kilogram of tissue, but hydrolyzes 3 to 4 kg of ACh per kilogram of tissue per hour. A several-hundredfold purification was obtained in the 1940's [M. A. Rothenberg and D. Nachmansohn, *J. Biol. Chem.* **168**, 223 (1947)]. The availability of the enzyme permitted the analysis of molecular groups in the active site by kinetic studies [D. Nachmansohn and I. B. Wilson, *Advance. Enzymol.* **12**, 259 (1951)], information essential for understanding the mechanism of action of many important drugs, for example, organophosphate insecticides and nerve gases.

Recently a procedure suitable for large-scale enzyme preparation was described [*Proc. Nat. Acad. Sci. U.S.* **57**, 446 (1967)]. From 10 kg of material, 60 to 70 mg protein, shown to be homogeneous by disc electrophoresis and ultracentrifugation, with a specific activity of ~ 750 mmole of ACh hydrolyzed per milligrams of protein per hour and a molecular weight of ~ 240,000, are obtained. Crystals of the enzyme were obtained from a concentrated protein solution in ammonium sulfate at 4°C. The crystals are hexagonal rods; photographs (taken with Dr. Albert Kleinschmidt) will be shown. The rod length, originally less than 10 μ, has already grown under various conditions to nearly 100 μ, in preparation for X-ray crystallography. Preliminary observations suggest six active sites per molecule; other protein properties will be described.

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Trapped Rare Gases in Meteorites

Six rare-gas components are found to be present in meteorites. Four of these components were formed in place by nuclear reactions, namely, the radiogenic, fission, spallation, and neutron-capture components. The other two components have a different origin. One of those has relative elemental abundances which are close to the cosmic ones. The distribution of the gases and their diffusion properties suggest an irradiation of the individual grains by the solar wind. Evidence for a solar wind origin is found in the case of the enstatite achondrites. The other trapped rare-gas component is very strongly fractionated in the elemental abundances, but reveals no fractionation in the isotopic composition, which excludes a fractionation in a gravitational field or by diffusion. This component can best be explained by a selective trapping mechanism of primordial gases, probably by adsorption at low temperature.

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Chemistry of Antheridiol (Hormone A), a Sex Hormone of the Water Mold, Achlya bisexualis

Sexual reproduction in the water mold *Achlya bisexualis* is initiated by a diffusible substance secreted by the female mycelium which brings about the formation of antheridia in the male. From culture liquids of the female mold, an extract was obtained which, after separation by thin-layer chroma-

tography or countercurrent distribution, gave a highly active crystalline compound named antheridiol (hormone A).

A high-resolution mass-spectrometric analysis of this compound suggests that it is a steroid. Further evidence (ultraviolet, infrared, nuclear magnetic resonance, and mass spectra) on antheridiol and its derivatives is discussed in terms of a proposed structure.

Work done in collaboration with G. Arsenault, K. Biemann, and Alma W. Barksdale.

T. C. McMorris
New York Botanical Garden

Evolutionary Divergence in the Frog, Rana pipiens

Androgenetic hybridization, the development of an enucleated ovum with the paternal chromosomes only, has been the main tool in a new cycle of experiments on evolution within the *Rana pipiens* complex. These frogs range over most of North America, and many of the local populations differ from one another in morphology and physiology. Numerous diploid crosses have revealed a high degree of incompatibility between individuals, on the one hand, from localities in a broad arc beginning in New England and extending west to the Rocky Mountains and then down the highlands of Central America to Costa Rica and, on the other hand, from the Gulf Coast lowlands of the United States and Mexico. By contrast, hybrids of individuals from localities within this broad arc, even as distant as Vermont and Costa Rica, develop normally past metamorphosis. Such observations suggest a high degree of genetic compatibility. The development of androgenetic hybrids suggests much less compatibility: development is usually highly abnormal even where the diploid hybrids are normal. Androgenetic hybridization, therefore, appears to be a delicate measure of the ability of chromosomes of one population to function in the cytoplasm produced under the influence of the chromosomes of another population. The data on diploid and haploid hybridization suggest strongly that, in some localities, adjacent populations of the *Rana pipiens* complex have diverged to such an extent as to preclude hybridization in nature.

John A. Moore
Columbia University

Ion Passages in Lipid Bilayers

Evidence from electron micrographs and measurements of electrical impedance have led to the widespread belief that the membranes of living cells contain two layers of lipid molecules whose hydrocarbon chains fill the interior of the membrane, while the polar end groups are anchored by the aqueous phases of the cellular lumen and the intracellular space or other natural liquid environment. Artificial membranes assembled from natural lipids exhibit greater impedances than natural ones. The imitation is improved by the addition of membrane lipoproteins, which facilitate the passage of ions and may augment the electrostatic capacity. The observed inhibition of transport by small quantities of poison indicates that the permeability depends on local "pores." For a specific model, it is suggested that nonrigid ion passages are formed from chains of polar groups belonging to the side chains of amino acids such as aspartic and glutamic acids, serine, threonine, and possibly imidazole and others. The supporting polypeptide helices are held in position by suitable placement of nonpolar and polar groups; the chain-forming groups help to bind different helices together. While the theoretical analysis is somewhat incomplete and speculative, the results so far are encouraging.

Lars Onsager
Yale University

Chemical Signaling between Polyphemus Moths and between Moths and Host Plant

Oak leaves produce an emanation which provokes the mating of the oak silkworm, *Antheraea polyphemus*. The agent in question is a heat-stable, water-soluble substance which has been extracted and partially purified. The "oak factor" acts exclusively on the antennae of the female moth to trigger the release of the female's sex attractant by glands at the tip of her abdomen. This second volatile material then diffuses over substantial distances and acts on the antennae of the male moth to provoke the latter's oriented flight to the female. By virtue of these arrangements, the mated female automatically finds herself in the vicinity of appropriate host plants on which she deposits her eggs.

The action of the oak factor on the female can be masked by numerous other volatile agents including Chanel No. 5. The action of the sex attractant on the male can be completely and reversibly blocked by the vapors of formaldehyde.

The response of the female to oak factor, as well as the response of the male to the sex attractant, is eliminated by the prior excision of the corpora cardiaca. This finding suggests that the sensory input from the antennae to the brain then undergoes some sort of neuroendocrine relay within both male and female polyphemus moths.

Lynn M. Riddiford
Carroll M. Williams
Harvard University

Negative Pressure in Plants and Osmotic Mechanism

It has been established empirically that a solution ($1M$) in a turgor-free leaf cell is balanced by xylem sap (-24 atm), that is, the vapor pressure (activity) is lowered by the same amount in both compartments. The hydrostatic pressure of a body of water can be lowered by inserting into it a dilative material, whether this is a compressed noncavitating matrix (xylem) or solute molecules, provided these are kept confined by the free surface and are straining on it. In either case, balancing of forces requires that the hydrostatic pressure of the water (solvent) becomes lowered by an amount equal but opposite to the matrix or solute pressure. In an osmotic system at equilibrium, therefore, the hydrostatic pressure of the solvent, acting like a hydraulic fluid, is the same in all compartments; this is why the vapor pressure is also the same. Living cells and xylem sap in a nontranspiring mangrove has the same hydrostatic solvent pressure (-25 atm) as the sea water. This hydraulic concept gives a simple and sufficient explanation of the lowering of the vapor pressure over a solution. It explains why water, or a permeant solution, moves through the membrane into a nonpermeant solution as rapidly as under an equivalent hydraulic pressure difference. It does away with the contradictory postulate that osmotic equilibrium maintains a hydrostatic solvent gradient across the membrane without flow.

P. F. Scholander
Scripps Institution of Oceanography

"Try Simplest Cases" Approach to the Heredity-Poverty-Crime Problem

A famous "try simplest cases" approach [W. Shockley and W. Gong, *Mechanics* (C. E. Merrill, Columbus, Ohio, 1966)] explained the properties of matter by assuming it consisted of indestructible atoms of elements. This simple model, although known to be a gross oversimplification since radioactivity was discovered, remains a basis for chemistry and metallurgy. In contrast, the simple explanation of the god Thor as the cause of thunder and lightning is practically worthless. A simplest-cases approach to human population problems suggests that modern advances in medicine and technology can upset quantitative and qualitative aspects of humanity and possibly endanger the future of civilization. Developments in control of human reproduction are now openly discussed and promise to solve the quantity problem. Facts from the science of behavior genetics suggest that welfare cases may be producing an increasing percentage of the unemployable, but this quality problem, insofar as it involves intelligence and heredity and especially questions of racial differences, now seems so emotionally charged as to be intellectually unapproachable. My experience confirms the existence of the effective suppression of objective discussion (including fear of loss of employment) that has been extensively documented recently. [C. Putnam, *Race and Reality* (Public Affairs Press, Washington, D.C., 1967)]. Two eminent exceptions are the recently expressed similar concerns of D. J. Ingle (AAAS meeting, December 1966; Columbia University Forum, in press) and H. F. Harlow (reported by W. Shockley, *S.F. Chronicle*, 30 January 1967). Harlow conjectures: "It is my opinion, and it is the opinion of many psychologists, that the average intelligence scores of people labeled 'black' are lower by about one standard deviation than the average of those labeled 'white' and I believe that at least half of this difference is related to genetic variables." Analysis of recent draft test data indicates that the difference has significantly increased between World War I and now. I can identify no serious efforts either individually or collectively in the National Academy of Sciences to replace the quoted "simplest cases" conjecture with sound facts.

W. SHOCKLEY
Stanford University

"Try Simplest Cases" Prediction of a Magnetic Current Force

In addition to the force exerted upon electric currents flowing in magnetic fields (such as drives electric motors), we propose an equally real but generally much smaller "magnetic current force" $\mathbf{f}_m$ exactly of the form expected if magnetism were produced by magnetic charges that "flow" when magnetism changes. (In MKS units $\mathbf{f}_m = \epsilon_0\mathbf{E} \times (\mathbf{B} - \mu_0\mathbf{H})$.) A "try simplest cases" treatment of "conceptual experiments" in an "idealized limiting case" [these "search thinking tools" are discussed in W. Shockley and W. Gong, *Mechanics* (C. E. Merrill, Columbus, Ohio, 1966) and in W. Shockley, *IEEE Spectrum*, **3**, 49 (1966)] of a superconducting coaxial transmission line revealed the need for $\mathbf{f}_m$ to transfer the electromagnetic momentum (that is, $\mathbf{G}_p$ = the integral of the Poynting's vector momentum density $\mathbf{g}_p = \mathbf{E} \times \mathbf{H}/c^2$) to mechanical momentum when the center conductor acquires resistance, and energy flow dies away. Conservation of momentum again requires $\mathbf{f}_m$ for a wave packet in a medium with magnetic-energy losses. The origin of $\mathbf{f}_m$ in actual magnetic materials in which magnetism is caused by current loops, not magnetic charges, arises from a generally neglected linear momentum $\mathbf{G}_I$ that must exist even within the pattern of the spinning electron's motion. D. L. Webster has considered this momentum for examples other than current loops (personal communication). This $\mathbf{G}_I$ is the momentum of an energy flow necessarily associated with any current loop lying in an electric field (that is, $-\mathbf{G}_I = \epsilon_0\mathbf{E} \times \mu_0 I\delta\mathbf{A} = \epsilon_0\mathbf{E} \times \mu_0\delta\mathbf{m}$.) This energy flow within a thin layer (or pill box) containing the current loop is necessary to avoid divergence of the total energy flux which, by the Einstein mass-energy relation ($E = mc^2$), corresponds to a mass flow; $\mathbf{G}_I$ balances the energy flow that is carried by Poynting's vector from places where the electric field opposes the current flow to places where it aids. Changes in magnetization change $\mathbf{G}_I$, and these changes appear as the force $\mathbf{f}_m = -\dot{\mathbf{g}}_I$. The energy flow for $\mathbf{G}_I$ can be understood for macroscopic models: (i) Insulated, rotating, circular disks with charged rims produce I and carry $\mathbf{G}_I$ as mechanical power flow. (ii) Charged, inertial masses produce I by sliding on frictionless tracks and carry $\mathbf{G}_I$ as kinetic energy. It is conjectured that $\mathbf{G}_I$ for electronic magnetism is the quantum-mechanical equivalent of (ii). The identity of $\mathbf{f}_m$ with the magnetic-charge model occurs because $\mathbf{G}_p$ within a magnetic charge dipole shell is mathematically equal to $\mathbf{G}_I$.

W. SHOCKLEY
R. P. JAMES
Stanford University

Extracellular Evolution of a Self-Duplicating Nucleic Acid Molecule

When $Q\beta$ replicase is presented with either of two genetically distinct $Q\beta$-RNA molecules, the RNA synthesized is identical to the initiating template [N. R. Pace and S. Spiegelman, *Science* **153**, 64 (1966)]. This outcome proved that the RNA is the instructive agent in the replicative process and hence that it satisfies the definition of a self-duplicating entity.

An opportunity was thus provided for studying the evolution of a self-duplicating nucleic acid molecule outside of a living cell. It should be noted that this situation mimics at least one aspect of the earliest precellular evolutionary events when environmental selection operated directly on the genetic material.

We report experiments which asked the question: What are the evolutionary consequences if the only demand made on the RNA molecules is that they multiply? To answer these and related issues, a serial transfer experiment was performed in which the intervals of synthesis were adjusted to select the earliest molecules completed. As the experiment progressed, the rate of RNA synthesis increased and the product became smaller. By the 74th transfer, the replicating molecule had eliminated 83 percent of its original genome to become the smallest known self-duplicating entity.

Aside from their intrinsic interest, such studies can provide insight into a number of central issues. Thus, they can tell us the smallest self-duplicating entity that can be constructed by such devices and provide much simpler objects for analyzing the replicative process. Further, the sequences involved in the recognition mechanism between template and enzyme must be retained, leading to their enrichment in the smaller molecules which evolve. Finally, these abbreviated RNA molecules have a very high affinity for the replicase but are no longer able to di-

rect the synthesis of virus particles. This feature opens up a novel pathway toward a highly specific device for interfering with viral replication.

S. SPIEGELMAN
D. R. MILLS
R. L. PETERSON
University of Illinois

Retine

Retine has been isolated, crystallized, and analyzed as *bis*-2,4-dinitrophenyl hydrazone (by Együd, Fodor, Sachetto, and Szent-Györgyi) and found to be a 2-keto-3-deoxyglucose.

A. SZENT-GYÖRGYI
Institute for Muscle Research, Woods Hole, Massachusetts

Meteorites from the Moon?

In 1959 at the spring meeting of the Academy I suggested that possibly stone meteorites were coming from the moon, basing the suggestion on the cosmic-ray ages and the polymict character of the meteorites. Since that time, considerable evidence in regard to cosmic-ray ages and K-A, U, Th-He ages has appeared in a very instructive way with evidence of loss of the gases. Solar wind gases have been found in the surfaces of the particles of some meteorites. Also, primordial gases have been found in the meteorites. This has led Wänke to suggest again that some of the stone meteorites may come from the moon. This evidence will be reviewed together with some modified suggestions. The surface regions of the moon can be interpreted as consisting of fragmented material, agglomerates of much the same type as the meteorites. The material turned up by the Surveyor pad has the appearance of carbonaceous chondritic material. A recent theory for the origin of the moon and the development of meteoritic material will be reviewed in this connection, indicating that an adequate model exists for explaining the evidence that these studies have presented. It will be emphasized that the space program should attempt to determine the chemical composition and magnetic properties of material on the surface of the moon.

HAROLD C. UREY
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Organic Nature of Atmospheric Condensation Nuclei

In our modern world, air pollution with combustion nuclei from all sorts of fires and combustion engines leading to concentrations of Aitken condensation nuclei (cn) of well over 10^5 cn per cubic centimeter seems to occur everywhere, from cities to rural highways to camping sites. Studies in several deserts (including Death Valley) and an isolated mountain valley have shown that (i) volatile organic matter (predominantly terpenes) is given off by all living and dying plants; (ii) this matter disappears through photochemical processes; (iii) it reappears within hours after sunrise as particulate matter, first as very small Aitken nuclei, followed within 1 to 2 hours by an increase in the medium-sized nuclei, and then by larger, charged nuclei. Ultimately, these nuclei can be filtered out mechanically, and are then clusters of electron-absorbing particles, ranging in size all the way from 1 to 100 μ in diameter. The particles can be seen to consist of loose agglomerations of still smaller particles, which also can be found to exist singly. These particles have been called combustion products, are high in carbon, but are present even in the absence of fires or combustion engines.

F. W. WENT
DAVID B. SLEMMONS
HUGH N. MOZINGO
University of Nevada

Individuality in Vitamin C Needs

For decades we have known that the lack of vitamin C causes impairment in many ways: loss of weight, anemia, extreme weakness in muscles including the heart, bones becoming thin and fragile, loosened teeth, and a tendency to hemorrhage into various tissues; in fact, the effects of deficiency are so diverse that practically every organ in the body is affected.

Over the years there have been persistent reports of the benefits of relatively large doses in connection with a variety of pathologies. A most credible recent report is that relatively large doses (500–1000 mg daily) are highly efficacious in treating back difficulties involving the discs and ligamentous structures.

A crucial question is: Do some individuals inherently require, in order to maintain health, much larger amounts of vitamin C than those commonly recommended?

To help answer this question we have studied a population of 102 guinea pigs at eight different dosages (0 to 3.2 mg per 100 g of body weight per day) of vitamin C intake. Our results indicate that the individual guinea pigs have highly variable needs. There is every reason to think that this variability carries over to the human species. Our results suggest the possibility that guinea pigs may have some (variable) ability to produce ascorbic acid endogenously. This requires further exploration.

It is our considered opinion that, because of lack of attention to individual needs, medical scientists are missing the important practical benefit from the use of vitamins and other nutrients in the treatment of a variety of diseases. In our country, there are very few centers where such possibilities are being explored.

ROGER J. WILLIAMS
GARY DEASON
University of Texas

Magnetic Lineaments and Crustal Structure in a Strip across the United States

A set of 20 aeromagnetic profiles for a strip 100 miles wide across the United States and its continental shelves reveals large anomalies of major crustal significance. The 20 profiles, which are spaced 5 miles apart, were flown along great circle arcs and centered at Washington, D.C., on the east, and San Francisco, California, on the west.

The gross structure of the North American continent is such that this strip crosses at right angles most of the major tectonic elements from the Appalachian Mountain system in the east to the Rocky Mountains, Basin and Range province, and the mountain systems of California in the west.

A contoured aeromagnetic map of the transcontinental strip shows several significant trends. In the west, a northwesterly magnetic grain is associated with the Pacific Coast range, the Sacramento Valley, and the Sierra Nevada. In the east, a northeasterly magnetic grain is associated with the Blue Ridge and Piedmont provinces. East of the Sierra Nevada, the aeromagnetic data show a pronounced east-west grain as far east as Nebraska.

Of considerable interest is the occurrence of linear, steepened magnetic gradients which are especially pronounced. They are east-west in direction and extend as much as several hundred miles in length. Just south of San Francisco, an east-west lineament that is 400 miles long and extends eastward from the San Andreas fault may be related to the Mendocino fracture.

We suspect that these east-west lineaments may be related to fractures or fracture zones, some of which originate deep in the earth's crust, and that they may be genetically related to the system of east-west fractures which have been discovered over the oceans in the past decade.

To investigate the deeper part of the earth's crust, an aeromagnetic map which effectively filters out the magnetic anomalies of short wavelength has been compiled. Except for the continental margins, there is an east-west grain over most of the continent. It may be that the emplacement of magnetic material causing these anomalies may be controlled by an east-west system of fractures located in the deeper part of the earth's crust.

ISIDORE ZIETZ

U.S. Geological Survey, Silver Spring, Maryland

Biochemical Test of the Operon Model

A cell-free system for DNA-directed peptide synthesis has been developed; the system chosen for study was the enzyme β-galactosidase of *Escherichia coli*. Previous attempts have been made to synthesize this enzyme, but the incorporation systems were comparatively poor and the evidence was lacking in rigor, so that these attempts can be discounted. β-Galactosidase has a molecular weight of 535,000 and is known to be a tetramer containing 1170 amino acid residues. Because the monomer is so large, systems were sought in which only a fragment of this long polypeptide chain could be detected. Such a system is available which will allow for detection of the first portion of the chain called α. This is accomplished by intracistronic complementation—one mixes an extract containing α with an extract from a mutant containing a deletion of α. The complemented product, unlike either of the components, displays enzymatic activity. The critical macromolecular components in the synthetic system include DNA from the virus ϕ80dlac and a subcellular extract prepared from a mutant of *E. coli* containing a deletion of the lac operon and its *i* gene repressor. The synthesis of the α-fragment is detected by the complementation scheme referred to above.

The α-fragment is adjacent to the operator which is believed to be the primary site of action of repressor. This system has been used to study the action of repressor. Partially purified repressor prepared from an *E. coli* mutant containing two copies of the repressor gene have been used to inhibit 80 percent of the synthesis of α. This inhibition is largely reversible by $10^{-3}M$ isopropyl-β-D-thiogalactopyranoside (IPTG), which is a most potent inducer of the lac operon in vivo. The inhibition of α-synthesis is greater if repressor is mixed with the DNA before RNA and protein synthesis are allowed to proceed. This demonstrates unequivocally that the primary site of action of repressor is the DNA and not the messenger RNA.

This is the first time that it has been possible to demonstrate DNA-directed synthesis of a naturally occurring peptide in a cell-free system, and also the first time it has been possible to demonstrate the effect of repressor in a cell-free system. The results tend to support the operon model for regulation of protein synthesis.

GEOFFREY ZUBAY, JOANNE K. DEVRIES
MURIEL LEDERMAN

Columbia University

MEETINGS

Radiation Protection

Protection for atomic workers against radiation hazards has been a major concern of health physicists ever since the splitting of the atom over 20 years ago. Various work procedures and dosimetry systems have been developed to guard against and monitor exposure. Research on such methods and equipment was reported at the Symposium on Neutron Monitoring for Radiological Protection (Vienna, Austria, week of 29 August 1966) and the First Congress of the International Radiation Protection Association (IRPA) (Rome, Italy, week of 5 September 1966). At the Vienna symposium 151 delegates from 26 countries attended; at the Rome meeting 800 full members represented 40 countries.

Symposium on Neutron Monitoring for Radiological Protection

One of the major topics of interest was the Andersson-Braun dosimeter. Attention was directed toward reducing the size and weight of this portable neutron survey meter, which otherwise was much favored by the participants. Accordingly, two sequels to the Andersson-Braun dosimeter were described by J. W. Leake (Atomic Energy Research Establishment, Harwell, United Kingdom).

The first of these dosimeters, now available in commercial form from Isotopes Development Company (U.K.), utilizes a LiI (Eu) detector in place of a BF_3 tube. The crystal separated by a cadmium shield is surrounded by a double polyethylene moderator system. Although the weight of the instrument is reduced from 11.4 to 6.4 kg, the response is changed appreciably, especially for neutrons below 200 kev, where the dose is overestimated. The overestimate is by a factor of 3.5 for 5-kev neutrons and 3.25 for thermal neutrons. The instrument can also be used in pulsed fields where the pulse rate in pulses per second does not exceed the dose rate in millirems per hour.

The second instrument described by Leake contains a mean-current ionization chamber filled with $^{10}BF_3$ gas. The Andersson-Braun-type moderator is used, so that there is no reduction in weight. However, this instrument can be used around pulsed radiation sources. In mixed neutron-gamma fields, two readings are required to assess both neutron and gamma dose.

One interesting concept with regard