National Academy of Sciences

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Electric Power from Solar Radiation

Prior art presents limited collection of solar rays, in costly apparatus, suitable for special purposes. Author has invented a simple, inexpensive method for collecting unlimited quantity of solar radiation and converting it directly into electric power with a good percentage efficiency of conversion.

CHARLES G. ABBOT
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Cause of Gastric Ulcers

It has now been generally accepted that duodenal ulcers are caused by a hypersecretion of gastric juice of nervous origin caused by the stress of modern life. Hypersecretion of nervous origin does not occur in gastric ulcer patients, and it has been proposed that in them a hypersecretion of gastric juice of hormonal origin is the culprit. Food in contact with the antrum or lower portion of the stomach liberates the hormone gastrin which stimulates gastric secretion. Stagnation of food in the stomach causes prolonged liberation of gastrin and hypersecretion. We have been able to produce chronic gastric ulcers in rabbits and swine by cutting the vagus nerves to the stomach, an operation which causes decreased motility of the stomach and gastric stasis. When vagotomy is employed in the surgical treatment of duodenal ulcers, gastric ulcers have been produced when stasis of food was not prevented by an ancillary drainage operation.

LESTER R. DRAGSTEDT
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Biochemical Evidence for the Incorporation of Nucleotides during the Rejoining of Bacteriophage DNA Fragments

There is indirect evidence that the processes of genetic recombination and repair of DNA involve an end-to-end joining of the strands of DNA, require the synthesis of a short stretch of oligonucleotide, and can occur in the absence of semiconservative replication of a new strand. We have obtained direct biochemical evidence consistent with this process. *Escherichia coli* was grown in a medium containing dBrUrd and infected at 43°C with a temperature-sensitive DNA polymerase mutant of T5 labeled with ^{32}P. Under these conditions DNA replication should be inhibited, but if some replication of DNA occurred, this DNA would have a higher density than the parental DNA. DNA was extracted quantitatively, and the parental ^{32}P-T5 DNA was shown to remain intact. Yet, under these conditions dBrUrd was incorporated into parental T5 DNA. The DNA was purified and divided into two fractions; one fraction extensively hydrolyzed to 5′-nucleotides and the other to 3′-nucleotides. Only 3′-dBrUMP, and not 5′-dBrUMP, contained some ^{32}P. This indicates that the parental strands were broken, yielding fragments phosphorylated at the 5′-end of the broken point. In the rejoining of the broken strands, which were ^{32}P-labeled, a nucleotide incorporated adjacent to the 5′-phosphate terminus would be recovered as a 3′-nucleoside monophosphate containing ^{32}P. This is consistent with the idea that for rejoining of DNA fragments there must be the synthesis of a short stretch of oligonucleotides between such fragments. About 25 3′-^{32}P-dBrUMP molecules were incorporated per T5 DNA molecule; from this value, it can be estimated that the average total number of joints per molecule is about 200.

Sponsored by the Atomic Energy Commission under contract with the Union Carbide Corporation.

R. K. FUJIMURA
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Oxygenation: A Specific Soluble Cytochrome P-450 Coupled Enzyme Complex

Oxygen is incorporated directly into metabolites by enzyme systems found in liver microsomes, adrenal mitochondria, and numerous microorganisms. Many drug "detoxifications," the synthesis of steroid hormones, and the conversion of hydrocarbons to alcohols, including terpenes, and the terminal (ω –) methyl carbon of fatty acids, proceed by this mechanism.

A model monoxygenase [S (substrate), O_2, D(T)PNH→H_2O, S · O (product), D(T)PN] comprised of a soluble three-enzyme complex is found in *Pseudomonas putida* grown on the terpene, camphor. The substrate- and oxygen-binding component P-450_{CAM}, a protoporphyrin-IX hemoprotein, exhibits the spectral properties of the particulate mammalian P-450's with substrate in the oxidized form and with CO in the reduced form. The spectrally determined camphor-binding constant and K_m are about $10^{-5}M$ and show the blue shift characteristic of type-1 difference spectra; with aniline a type-2 difference red-shift spectrum is observed with a binding constant about $10^{-3}M$ [Imai and Sato, *J. Biochem.* **62**, 239 (1967)]. Putidaredoxin, a labile sulfur protein (mol wt 12,000) with a 2 Fe, 2 S paramagnetic active center, couples an electron transfer to P-450_{CAM} (mol wt 41,000) and is reduced by a DPNH flavoprotein (mol wt 39,000). Mössbauer measurements of putidaredoxin show a pure quadrupole interaction in the oxidized state and a strong magnetic splitting in the reduced, suggesting that the two covalently bound iron atoms are in equivalent sites and close enough to each other to interact strongly.

The electron flow from DPNH in the complex is substrate-dependent. In the presence of specific substrate, (+) or (–) camphor or the 1,2 lactones, the

shifts in absorption bands correlate with DPNH oxidation and product formation.

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University of Illinois

Patterns of Mental Ability and Socioeconomic Status

Children of low socioeconomic status (SES) whose IQ's are in the range below 90 on standard intelligence tests are found to be very different from middle-class children of the same IQ's in learning abilities. Low SES children of relatively low measured IQ are generally markedly superior to their middle-class counterparts in IQ on tests involving free recall, serial learning, paired-associate learning, and digit span.

Low SES children of average IQ or above, on the other hand, do not differ from their middle-class counterparts in these associative learning abilities.

This interaction among IQ, associative learning ability, and socioeconomic status has been demonstrated in children sampled from Caucasian, Mexican-American, and Negro populations. Social class and ethnic differences in the patterns of correlations among various mental tests have also been found.

The results of these studies are interpreted in terms of a hierarchical model of mental abilities going from associative learning to conceptual thinking, in which the development of lower levels in the hierarchy is necessary but not sufficient for the development of higher levels. The extent to which the development of higher levels in the hierarchy is influenced by the nature of environmental inputs has crucial educational implications [A. R. Jensen, *Amer. Educ. Res. J.* **5**, 1 (1968)].

ARTHUR R. JENSEN
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Information Processing in Fish Lateral-line Sense Organs

Two kinds of nerve terminals of the lateral-line organ have already been found in *Lyncozymba nystromi* (Japanese sea eel) as in the mammalian cochlea (Hama, 1965). The partly isolated lateral-line nerve was cut, and single-fiber preparations were obtained from both the central and peripheral cut ends. The remaining bundle of the peripheral cut end was used for electrical stimulation. Vibratory mechanical stimulation was delivered in the receptive field of the isolated single afferent fiber of the peripheral cut end. Spontaneous discharges of both afferent and efferent fibers could be recorded. Histograms and autocorrelation of a series of discharge intervals were calculated.

Although visual inspection did not reveal any obvious effects, the above statistical treatments showed cyclic change of intervals of spontaneous discharges in connection with heart beat, lymph-heart beat, and respiratory gill movement. Repetitive electrical stimulation of the nerve bundle, as mentioned above, produced an inhibitory effect on the spontaneous as well as the response discharges to vibratory stimuli, depending upon stimulus parameters, that is, pulse frequency, pulse size, and duration.

This feedback mechanism was not found in *Anguilla japonica* (Japanese common eel) electrophysiologically or electron microscopically. Why such a mechanism is found in the sea eel and not in the common eel is not certain at this time.

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Toroidal Magnetic Fields for Stable Plasma Confinement

The reason that toroidal multipole magnetic fields are of present interest for studies of plasma confinement is that the contained plasma is found to be quiescent. This now allows experiments on plasmas without fluctuations found in other closed systems. Internal potential and density fluctuations in an octupole are far less than their usual magnitudes. A diffusion coefficient derived from the fluctuations, when they could be measured, was much smaller than usually found [D. M. Meade, *Phys. Rev. Lett.* **17**, 677 (1966)]. Only for 200 μsec after plasma injection are there violent fluctuations while the plasma settles down to quiescence. These fluctuations are due to electric polarization by plasma motion across magnetic field. They are not present later in the contained plasma [W. E. Wilson and D. M. Meade, *Bull. Amer. Phys. Soc.* **9**, 495, 532 (1964)]. The continuing study of oscillations created under certain conditions is important in the search for any instabilities which might lead to loss of plasma by fluctuating electric fields. However, present experiments are not completely satisfactory for assuring that plasma loss is small enough for practical thermonuclear reactors, since there are supports passing through the plasma to hold multipole conductors within the plasma. These limit plasma life to 500 μsec. Equipment is being assembled with supports removable during the experiment to search for other losses and instabilities; and tests with added toroidal fields may lead to stellerator-like fields which need no internally supported conductors. Densities of 10^9 to 10^{11} ion/cm^3, and 50-volt ion and 10-volt electron temperatures can be created by gun injection or by microwaves.

Work supported by AEC.

D. W. KERST
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Utilization of Accentuated Environmental Inequalities in Research on Racial Differences

Wide disagreement exists on the importance and influence of socioeconomic factors on scholastic performance and group intelligence. Massive government-sponsored programs involving environmental remedies are being proposed to uplift all presently disadvantaged minorities without regard for the role of genetic determinants.

Examination of census and other pertinent statistical data indicate that American Indians currently lag behind American Negroes approximately as far as Negroes lag behind whites. Despite visibly greater handicaps in terms of family income, life expectancy, years of education, and employment opportunities, Indian school children generally outperform Negroes on scholastic tests, as revealed in the *Coleman Report* ("Equality of Educational Opportunity," Washington, D.C., 1966). This superior achievement is maintained in the face of distinctly inferior motivation, as measured by an inventory of questions in the above report.

The operation of other cultural and historical forces, in addition to the

language handicap, is not proportionately reflected in Indian scholastic ability. A survey of recent tests of ethnic potential suggests that Indians respond rapidly to minor improvements in environmental conditions. This is in contrast to considerable evidence that the gap between Negro and white scores is increasing despite marked socioeconomic advances by Negro citizens.

The argument is entertained that ethnic groups with different genetic endowments will progress at different rates in response to the same environmental benefits. The expectation that ethnic potential can be equalized by any amount of social engineering thus appears implausible.

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Action of Sodium Acetylsalicylate upon Body Temperature of the Cat

Salicylate antipyresis is rapid and effective in fibrile patients, rarely demonstrable at normal temperature. Hyperpyrexia is prominent in salicylism, usually only after repeated large doses. Salicylates are indiscriminately employed by the laity for every conceivable ailment. Cats, unlike people, may be assumed to be naive with respect to prior use of salicylates. The effects to be described obviously are acute.

Cats (chloralose-urethane anaesthesia) were injected intravenously with sodium acetylsalicylate (NaA, obtained from Dr. R. K. S. Lim) in doses of 100, 30, and 10 mg/kg. Temperature was measured, by thermistor, for 2 hours prior, and 3 hours subsequent, to injection. Maximal control variation was 0.3°C. Effects in given circumstance are qualitatively identical regardless of initial temperature (37°–45°C).

In intact animals, NaA (100 mg/kg) raised the temperature rapidly and progressively in degree (max. 2.5°C) roughly inversely as initial temperature. NaA (30 mg/kg) lowered their temperature rapidly and progressively in degree (max. 2.5°C) roughly inversely as initial temperature. NaA (10 mg/kg) was without effect. In decapitated animals, NaA (100 mg/kg) raised the temperature as before (max. 3.3°C). NaA (30 mg/kg) *raised* temperature to lesser degree (that is, effect is reversed). NaA (10 mg/kg) was without effect.

Decapitated animals are deprived of heat-regulating centers. General tissue response to aspirin (? uncoupling oxidative phosphorylations) increases temperature. Central action lowers temperature. Effect of aspirin in intact animal is a resultant of conflict. In decapitated animals, only tissue effect is operative, and only temperature increase is found. Unanswered questions are: how does aspirin lower temperature in face of tissue response in nonpanting, little-sweating cats? If this is hypothalamic thermolytic action in tissues, how does the hypothalamus reverse or countervene tissue thermogenic action?

Supported by NINDB research grant NB02816.

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Behavior of a Collisionless Plasma Confined by a Toroidal Multipole Magnetic Field

Measurements of the plasma losses from a toroidal octupole indicate that most of the plasma was lost on the internal hoops and their supports. A series of experiments was undertaken to infer the intrinsic confinement properties that the toroidal octupole would have if the supports which cross the plasma could be removed. When all the supports were shielded from the plasma by magnetic dipole guards, the plasma confinement did not change appreciably. The magnetic guards reduced the plasma losses on the supports effectively but introduced additional losses of comparable magnitude. In the central confinement region, the maximum diffusion coefficient due to the observed plasma fluctuations was roughly 10^{-3} lower than the rate for Bohm diffusion which has been present in most toroidal confinement experiments. Near the extreme edge of the plasma, the magnetic field shape was adjusted to create a theoretically unstable state. In this region the maximum diffusion coefficient due to the observed plasma fluctuations was the order of Bohm diffusion, indicating that the shape of the magnetic field was important in determining the fluctuation level in the plasma. A direct measurement of the plasma losses toward the outside wall indicates that without supports the plasma lifetime should increase by an order of magnitude if this were the only loss. This long lifetime would make the toroidal octupole interesting for thermonuclear plasma containment.

Work supported by AEC.

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Proteins in Bioelectrogenesis: The Control of Ion Movements in Excitable Membranes

Two major developments of the last decade have strongly influenced research on the proteins controlling permeability changes in excitable membranes. (i) Information has been accumulated about cellular membranes by means of electron microscopy combined with biochemical and biophysical analyses. These membranes are the sites of a great diversity of enzymatic activities (as, for example, mitochondrial membranes); they are structurally organized as a mosaic of functional units formed by lipoprotein complexes. (ii) Studies have been done on the conformation of macromolecules and their interaction with ligands and other macromolecules and the description of allosteric phenomena.

Electric organs have been used for studying the proteins involved in bioelectrogenesis: due to their high specialization, their excitable membranes comprise a major part of the cell mass, rendering them particularly suitable for studying functional proteins.

Acetylcholine (ACh) initiates the sequence of reactions increasing the permeability of excitable membranes to ions, the carriers of bioelectric currents; Ca^{++} is known to be involved in excitability. It is proposed that ACh is recognized by a specific protein, the ACh-receptor. The conformational changes of this protein induced by ACh lead to a release of Ca^{++}, which may induce conformational changes of the membrane phospholipids, thus amplifying the ACh signal and increasing permeability. ACh-esterase inactives ACh: the ion barrier is then reestablished [D. Nachmanson, *Chemical and Molecular Basis of Nerve Activity* (Academic Press, New York, 1959); *Ann. N.Y. Acad. Sci.* **137**, 877 (1966); *Bull. Soc. Chim. Biol.* **49**, 1177 (1967)].

The large-scale purification and crystallization of ACh-esterase from electric organs [W. Leuzinger and A. L. Baker, *Proc. Nat. Acad. Sci. U.S.* **57**, 446 (1967); W. Leuzinger, A. L. Baker, E.

Cauvin, *ibid.*, in press], has allowed studies on the structure and function of the protein. Information about the ACh-receptor protein has been obtained with the monocellular electroplax preparation [E. Bartels, *Biochim. Biophys. Acta* **109**, 194 (1965); ——— and D. Nachmansohn, *Biochem. Z.* **342**, 359 (1965); T. R. Podleski and D. Nachmansohn, *Proc. Nat. Acad. Sci. U.S.* **56**, 1934 (1966); *ibid.* **58**, 268 (1967); ——— and J. P. Changeux, *Science* **157**, 1579 (1967); J. P. Changeux, *et al., Proc. Nat. Acad. Sci. U.S.* **58**, 2063 (1967); ——— and T. R. Podleski, *ibid.*, in press; A. Karlin and E. Bartels, *Biochim. Biophys. Acta* **126**, 525 (1966); H. I. Silman and A. Karlin, *Proc. Nat. Acad. Sci. U.S.* **58**, 1664 (1967); *ibid.*, p. 1162; ——— and M. Winnik, *ibid.*, in press; ———, *J. Theoret. Biol.* **16**, 306 (1967)]. These proteins will be discussed.

DAVID NACHMANSOHN
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Influence of Atmospheric Stability Layers on the Effect of Ground-Based Cloud Seeding: I. Empirical Results

Efforts to augment precipitation by cloud seeding with AgI are based on its ice nucleating activity in liquid clouds below −4°C. If seeding is done from the ground, success would require that updrafts carry the AgI into supercooled clouds before it is disintegrated by photolysis. Temperature inversions and isothermal layers are barriers to convective updrafts and would be expected to prevent ground-based AgI seeding from being effective. This expectation is contradicted by the Swiss randomized experiment Grossversuch III, conducted on the southern slope of the Alps with seeding from the ground. The experiment was restricted to 292 days on which forecasters expected thunderstorms. Teletype messages from noon radiosondes at Milan are available for 287 days.

On 97 days there were no stability layers, and large increases in rain were expected due to seeding. In actual fact, seeding appears to have decreased the average rainfall from 12.6 to 8.1 mm, with significance probability $P = 0.15$. Even more unexpectedly, on 76 days with inversions or "thick" isothermals occurring at warm temperatures, the seeding increased the whole-target rainfall from 7.8 to 16.7 mm with $P = 0.054$. For the Magadino Valley the increase is from 7.7 to 21.4 mm with $P = 0.025$. In the absence of stability layers, hail fell on 32 percent of the days with or without seeding. In the presence of inversions, there was an increase in the frequency of hail days ascribable to seeding from 22 to 43 percent with $P = 0.056$.

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Influence of Atmospheric Stability Layers on the Effect of Ground-Based Cloud Seeding: II. Hypotheses in Explanation

The remarkable discovery by Neyman *et al.* that "warm" stable layers augment rather than inhibit the rain-stimulating effect of ground-based AgI smoke generators raises serious questions as to whether the way AgI affects the precipitation process is the one commonly accepted or whether the stable layers prevent upward air motions in the fashion ordinarily assumed. Ways for AgI to work at warm temperatures will be presented, but the more probable explanation of the effect lies in the fact that heating at the mountain slopes or convergence at fronts would eliminate the stable layers there and cause upslope currents which would carry the AgI into convective clouds where temperatures are low enough for it to be effective. The stable layers would keep the AgI smoke from becoming diluted, so that it would rise above the mountains in concentrations adequate to produce sizable effects. The lack of significant effects in the absence of low warm stable layers may be due to the fact that the seeding agent becomes too dilute because vertical mixing takes place over a widespread area instead of only over the mountain slopes.

The 76 days with warm stable layers included eight seeded and 14 unseeded with northerly flow, which is associated with small precipitation amounts, and ten seeded and seven unseeded with strong southerly flow, with which large amounts occur. Both inequalities tend toward more rain or seeded days. However, when the days with northerlies and strong southerlies were omitted, there was still a 62 percent excess on seeded warm inversion days.

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Metal Site of Nonheme (Iron-Sulfur) Proteins

Hyperfine splitting (hfs) in the electron paramagnetic resonance (EPR) spectra of the reduced form of iron sulfur proteins from *Azotobacter* and *Pseudomonas* [*Proc. Nat. Acad. Sci. U.S.* **52**, 1263 (1964); *Biochem. Biophys. Res. Commun.* **26**, 569 (1967)] is observed on isotopic replacement, ^{56}Fe by ^{57}Fe, or ^{32}S by ^{33}S. Thus, unpaired spin density occurs on both iron and sulfur atoms. Analysis of the well-resolved hfs after ^{57}Fe (nuclear spin $I = 1/2$) substitution in these proteins from *Pseudomonas* (mol wt 12,000) and from adrenals ("adrenodoxin," mol wt 15,000)—two Fe and two S (labile) each—showed interaction of one unpaired e^- with two Fe atoms (*Proc. Nat. Acad. Sci. U.S.*, in press; *Ann. N.Y. Acad. Sci.*, in press). Similar analysis with sulfur was hampered by lack of highly enriched ^{33}S isotope and the more complex hfs ($I = 3/2$). A successful quantitative replacement of labile sulfur by selenium (^{80}Se, $I = 0$; ^{77}Se, $I = 1/2$) in the *Pseudomonas* [*Biochem. Biophys. Res. Commun.* **30**, 323 (1968)] and adrenal protein permitted the analysis of hfs with the 77 isotope and showed interaction of two Se atoms (and by inference two S atoms) with the unpaired e^-.

One e^- is taken up per molecule on anaerobic reductive titration and is quantitatively accounted for on integration of the EPR signal. Therefore, one unpaired electron is shared by two Fe and two S atoms. Whether nonlabile sulfur atoms share the unpaired e^- should be discernible by growth on ^{33}S-isotope followed by exchange with labile ^{32}S.

The hfs observed in the EPR spectrum of isotopically substituted iron-sulfur proteins has revealed the stoichi-

ometry of the paramagnetic complex that is the outstanding common feature of these proteins.

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Density Distribution in the Earth

Earth models selected by a Monte Carlo procedure are tested against geophysical data. Five million models were examined, and six have passed all tests. Common features of successful models are an increased core radius, a chemically inhomogeneous core consistent with Fe- (20–50 percent) Ni alloy for the solid portion and Fe- (15–25 percent) Si for the fluid core. The mantle is inhomogeneous, consistent with an increase in the FeO/FeO + MgO ratio by a factor of 2 in the deep mantle. The transition zone is not only a region of phase change but also is a compositional boundary. This would inhibit mantle-wide convection. The upper mantle solutions show large density fluctuations. This implies insufficient constraint on solutions for this region or lateral variations in mantle composition ranging from pyrolite to eclogite.

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Influence of Atmospheric Stability Layers on the Effect of Ground-Based Cloud Seeding: III. Classification of Weather Types

According to Neyman *et al.*, the stability of air masses flowing toward mountains influences the effect of the AgI cloud seeding from the ground. The joint American-Swiss investigation suggests that the following classification of weather conditions might be useful:

1) Moist labile stratification of the air: (i) Labile stratification of the whole troposphere: the AgI particles rapidly reach high altitudes and cause local "overseeding." The precipitation is diminished. (ii) Labile stratification only in the lower part of the atmosphere extending up to a stable layer colder than −4°C: the AgI rapidly reaches the layer and spreads over a large area; precipitation is increased by seeding.

2) Moderate stratification of the air, perhaps with several isothermal layers: AgI is distributed in vertical and horizontal directions. When the air masses are lifted orographically, cloudiness and precipitation increase.

3) Stable stratification of the air (inversions) in warm temperatures: (i) In the absence of updrafts, no ice nucleation by AgI is possible. (ii) With updrafts (caused by frontal passages or orographic), the intercepting layer is destroyed, the AgI reaches temperatures in which it can nucleate ice crystals, and, as found empirically, precipitation is greatly increased.

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New Test of General Relativity: Preliminary Results

Several years ago it became evident that a new experimental test of general relativity was technically feasible [I. I. Shapiro, *Phys. Rev. Lett.* **13**, 789 (1964)]. The experiment was conceived to verify the prediction that the speed of propagation of electromagnetic radiation decreases as it passes through a region of increasing gravitational potential. For a pulse of radio energy transmitted from the Earth and reflected by either Mercury or Venus, calculations showed that the increase in the round-trip time delay, attributable to the predicted influence of the Sun on the speed of propagation, would be as large as 200 μsec if the path of the pulse were to graze the solar limb. Use of a radar frequency near 10 Ghz was expected to reduce the corresponding effects of the solar corona to a negligible level.

This experiment was carried out last year with the use of the Lincoln Laboratory Haystack radar which was specially instrumented to enable the round-trip time delays of radar pulses traveling between the Earth and Mercury to be measured with an uncertainty no greater than 10 μsec even when the planet was on the other side of the Sun from the Earth. In addition to estimating the (partially) unknown orbital parameters from the radar data, the coefficient of the "extra" delay in the theoretical formula for time delays was also estimated. A value of zero for this parameter λ would imply that light travels rectilinearly at a constant speed, whereas a value of unity implies that general relativity is correct. The experiment yielded $\lambda = 0.9 \pm 0.2$ [I. I. Shapiro, G. H. Pettengill, M. E. Ash, M. L. Stone, W. B. Smith, R. P. Ingalls, R. A. Brockelman, *Phys. Rev. Lett.*, in press)].

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A "Try Simplest Cases" Resolution of the Energy-Momentum Tensor Controversy for Electromagnetic Fields in Matter

The choice between the Abraham $\mathbf{g}_A \equiv \mathbf{E} \times \mathbf{H}/c$ and Minkowski $\mathbf{g}_M \equiv \mathbf{D} \times \mathbf{B}/c$ formulas for momentum density has puzzled relativity experts for many decades. Pauli (*The Theory of Relativity*, 1958) has stressed the difficulty of determining by measurement which form is correct because, in spite of the large factor $\varepsilon\mu$ difference between $\mathbf{g}_A$ and $\mathbf{g}_M$, the magnitude of the momentum is so small that "it is hardly likely that an experiment could be devised for deciding . . . ." Møller's classical Theory of Relativity reaches the same conclusion and leans heavily to $\mathbf{g}_M$. A "try simplest cases" approach, initiated while teaching a set of "mental tools for scientific thinking" [see Shockley and Gong, *Mechanics* (1966)] leads, by straightforward application of special relativity theorems on center of mass of closed systems, to the conclusion that in matter at rest the momentum density is unambiguously $\mathbf{g}_A$. Another simplest case involves a pulse of radiation entering normally into a nonreflecting medium composed of a periodic array of microscopic slabs parallel to the surface with average bulk properties $\epsilon = \mu = n$ the index of refraction. For this case the total momentum density is $n\mathbf{g}_A$ with $(n-1)\mathbf{g}_A \equiv \mathbf{g}_b$ resulting from bodily motion produced by the Lorentz force on the polarization current $(\epsilon - 1)\dot{\mathbf{E}} \times \mathbf{H}$ and its dual $(\mu - 1)\mathbf{E} \times \dot{\mathbf{H}}$ on "magnetic currents," the latter force arising from converting "hidden momentum" to bodily motion by mechanisms arising from Dirac electron effects

[Shockley, *Phys. Rev. Lett.* **20**, 343 (1967)]. A complete energy-momentum tensor can be written down for a hypothetical "cube-stuff" composed of a lattice of small cubes of ε,μ matter separated by thin cracks. In the cracks, the components of $\mathbf{E}_c$ equal that of **D** perpendicular to the crack faces and those of **E** parallel to the crack faces. The ratio of $\mathbf{g}_b$ to $\mathbf{g}_A$ depends on direction of propagation.

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Proposed Research to Reduce Racial Aspects of the Environment-Heredity Uncertainty

Human Genetics and Urban Slums (A Statement by the NAS Council, News Report, November 1967) asserts that (i) "in the absence of some now unforeseen way of equalizing all aspects of the environment, answers to" environment-heredity questions "can hardly be more than reasonable guesses"; (ii) "it is unrealistic to expect much progress unless new methods appear"; and (iii) "there is no scientific basis for a statement" about racial hereditary differences in intelligence. Assertion (iii) obscures the existence of scientifically established racial differences in neurological function (Negro babies outperform whites on early motor tests) [N. Bayley, *Child Develop.* **36**, 379 (1965)] and structure [E. Beck and D. C. Gajdusek, *Nature* **210**, 1338 (1966)] consistent with Carleton Coon's (*Origin of Races*) hypothesis of different evolutionary status. Concerning (ii), one new research technique [Stodolsky and Lesser, *Harvard Educ. Rev.* **37**, 546 (1967)] employs intelligence patterns (that is, relative performance levels on four tests: verbal, reasoning, numerical, spatial) that show pronounced ethnic differences in school children with ethnic patterns substantially invariant to socioeconomic level. Application of this technique to illegitimate Negro orphans from the ghetto (in their birth environment, they would have had low scores with verbal highest and numerical lowest) who have been adopted into middle-class Jewish families (very high scores with numerical markedly higher than reasoning or spatial) might enable a definitive test of such hypotheses as Washburn's [*Amer. Anthropol.* **63**, 521 (1962)] that for equal environments American Negroes might surpass whites. Assertion (i) is contrary to the history of science and technically unsound in rejecting possible research significance of the accentuated environmental disadvantages of American Indians (R. E. Kuttner and A. B. Lorincz, at this meeting).

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Study of Monozygous Quadruplet Armadillos in Relation to Mammalian Inheritance

Sixteen sets of newborn monozygous quadruplet armadillos were investigated from the standpoint of intraset differences. Twenty parameters were considered: body weight, scute number, adrenals weight, brain weight, heart weight, kidneys weight, liver weight, spleen weight, small intestine length, norepinephrine in the spleen, norepinephrine in brain, norepinephrine in adrenals, epinephrine in adrenals, percentage of catechol amines present as norepinephrine in adrenals, free aspartate, glutamate, glycine, alanine, GABA, and taurine in brain homogenate.

The maximum intraset differences ranged from 4 percent (scute numbers) to 140-fold (percentage of catechol amines present as norepinephrine in the adrenals). The maximum organ weight differences varied from 49 percent (liver weights) to 2.1-fold (spleen weights). The maximum differences in catechol amine content varied from 6.6-fold (norepinephrine in brain) to 32-fold (epinephrine in adrenals). The maximum differences in the free amino acids in brain homogenates varied from 77 percent (glutamate) to 5.5-fold (aspartate).

These large intraset variations and the other data obtained suggest that unknown extrachromosomal factors probably determine the extent to which various types of differentiated cells proliferate during embryological development (thus determining organ sizes and endocrine patterns) and that these factors may be exceedingly important in mammalian inheritance—particularly with respect to such characteristics as strength, speed, intelligence, fertility, and so on. The findings call attention to error which may be involved when monozygous human twins are considered as having identical inheritance.

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Immunological Properties of Colicine K

Cultures of *Escherichia coli* K_{235} induced with Mitomycin C (M) elaborate ten times as many units per milliliter of the bacteriocine colicine K (Col K) as bacilli grown in the absence of M do. M-induced Col K is a protein-like substance which has been obtained in nearly pure state. It has 40 times the activity of the Col K obtained from non-induced cultures of *E. coli* K_{235}. M-induced Col K evokes potent precipitating and neutralizing antibodies in rabbits. These antibodies are of three types. The first precipitates a component still present in the preparation of Col K which is without bactericidal activity. The second precipitates and neutralizes Col K itself, whereas the third neutralizes the bacteriocine without precipitating it. The latter comprises less than 10 percent of the total neutralizing antibodies. The three immune bodies can be separated. Thus, absorption of an antiserum with an antigen (C^-) derived from a noncolicinogenic mutant of *E. coli* K_{235} removes the nonspecific precipitating antibody, leaving the other two in solution. The Col K precipitating and neutralizing antibody can be removed by partial absorption with Col K, leaving the nonprecipitating neutralizing antibody. Gel filtration reveals that the neutralizing antibody is in the 7*S* γ-globulin and not in the macroglobulin fraction. Zone electrophoresis has shown that the nonprecipitating neutralizing antibody is located in the fast-moving fraction of the γ-globulins. Col K derived from M-induced cultures, unlike that obtained from cultures grown in the absence of M, does not appear to be associated with the O antigen of *E. coli* K_{235}.

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Chemical Analysis of the Lunar Surface at the Surveyor Landing Sites

Chemical analyses have been made of the lunar surface at the landing sites of Surveyor V, VI, and VII. Two of these sites are in mare-type regions of the Moon; the last is in the highland region near the crater Tycho. The samples examined have included relatively undisturbed lunar surface material as well as a plowed-up area and a lunar rock.

The newly developed technique of alpha-scattering chemical analysis was used. The energy spectra of backscattered alpha particles and of protons produced by (α,p) reactions determine the amounts of the chemical elements present in the sample.

In all the samples examined, preliminary results indicate that the most abundant elements are, in decreasing order, oxygen, silicon, and aluminum. At present, within the rather large estimated errors, the chemical composition at the two mare sites is the same. The samples at the highland site are also similar, with the only established difference being the lower abundance of elements with masses between 47 and 65 (including the elements Cr, Mn, Fe, Co, and Ni).

The chemical composition found at all three sites differs markedly from that of condensed solar material or of the majority of meteorites or of terrestrial ultrabasic rocks. The chemical composition of the mare samples resembles that of some terrestrial basalts and of the basaltic achondrite meteorites. The smaller amount of the heavier elements present in the highland sample than in the mare samples, if it is typical, may contribute to the higher albedo of the highland regions of the Moon. The results may also imply that the highland rocks on the Moon are less dense than those made up of mare-type material.

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Biological and Mechanical Role of Soil Fungi

Mycorrhiza, the symbiosis of roots of higher plants with fungi, has been known for a long time as an essential relationship for the growth of certain trees, orchids, and especially saprophytes. This relationship was usually considered bipartite—one in which the fungal hyphae partly replaced the root hairs (often lacking in the tree or orchid roots) and partly supplied growth factors to the roots, but in their turn the fungi were considered to receive much of their organic nutrition from the roots. Observations in the Amazonian rain forests and in deserts of the southwestern United States show that mycorrhiza is essentially a tripartite relationship, in which the fungi on the one hand decompose the forest and desert litter and then transfer the nutrients and minerals which they liberate to the tree, shrub, or orchid roots. Thus, the minerals present in the organic phase of the forest or the desert vegetation are circulated in a closed system so that little is lost by leaching and little needs to be resupplied from the sandy soils which are often very poor.

The ubiquitous fungi also play a second role, particularly in the sandy desert soils. There they serve to bind sand and silt particles into a coherent mass, which we call soil, and which is sufficiently firm to allow animals to burrow in it. This soil binding by hyphae is at least as important as the binding by root hairs, as will be demonstrated by photomicrographs of soils.

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Tetrodotoxin: A Nonlethal Paralytic Agent for Insects

"Puffer fish toxin" causes a flaccid paralysis when injected into insects in concentrations of about 0.5 μg per gram live weight. The heart continues to beat, and the muscles usually (but not always) remain sensitive to direct electrical stimulation even after the injection of enormous doses (in excess of 25 μg per gram). The paralysis is reversible in the case of cockroaches (*Periplaneta, Blaberus,* and *Leucophaea*), and all individuals recover within a period of 1 day to several days.

In the case of the diapausing silkworm pupae (*Samia cynthia, Antheraea pernyi, A. polyphemus, Hyalophora cecropia, H. gloveri*), the paralysis produced by a single injection of tetrodotoxin persists for many weeks without killing. Strangely, the paralyzed condition fails to interfere with the secretion of "brain hormone" by the neurosecretory cells of the pupal brain. Diapause is terminated, and adult development takes place to produce flaccid but otherwise normal moths. The continued presence of tetrodotoxin is documented by the ability of the moth blood to cause flaccid paralysis when transfused into pupae. The paralysis produced by a single or even by repetitive injections of tetrodotoxin also fails to interfere with the metamorphosis of the central nervous system, the trophic effects of nerves on muscle and myoblasts, or the brain-centered "clockwork" which controls the response of *Antheraea pernyi* to long- and short-day conditions.

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Analysis of Scientific Productivity

In a 1957 paper, Shockley analyzed statistically the productivity of scientists in several large laboratories, using the number of papers published over a given interval of time as a measure of productivity. He found the same typical statistical distribution in each case: extremely low productivity for the lower 50 percent of the scientists, with most of the total scientific production coming from the upper 20 percent. He further suggested that this type of statistical distribution would result if the scientific productivity could be expressed as a product of a number of factors.

The present paper analyzes in detail the concept that scientific productivity is a product of factors. In particular, the question is asked how many independent factors are in this product. Assuming that each independent factor has a constant statistical distribution from zero up to a maximum value, we find that a product of three such independent factors gives an essentially exact reproduction of the statistical distribution gathered by Shockley. Just what these three independent factors are is, of course, open to discussion.

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