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This Week in Science

Editorial

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Special Section

Frontiers in Material Science

No More “Heat, Beat, and Hope”
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Looking Eastward in Search of the Right Staff

Advanced Materials for Aircraft Engine Applications: D. G. Backman and J. C. Williams
Epitaxial Growth and the Art of Computer Simulations: H. Metiu, Y.-T. Lu, Z. Zhang

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Cover  Silicate glasses prepared with the sol-gel process that contain the encapsulated metalloproteins ferricytochrome c and ferrocyanochrome c, copper-zinc superoxide dismutase and its cyanide adduct, and metmyoglobin. For the samples arranged in a circular fashion, the outer circle consists of aged gels and the inner circle of the corresponding xerogels. See page 1113. This issue of Science focuses on advances in the design, synthesis, and processing of materials. [Photographs by Louis Meluso]

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Frontiers in Materials Science

Materials and materials science and engineering play a major role in science because these areas play a major role in our lives. Materials are critical in satisfying human needs as well as human desires. In this issue of Science, we explore some advances in the science and technology of materials, in part because of the broad, interdisciplinary aspects of the field but also because of its relevance.

A recurring theme in these articles is rational synthesis and process control. The ability to make molecules and materials with well-defined properties, under controlled conditions, is one of the important characteristics of modern molecular science. Significant progress in understanding chemistry and physics has enabled us to develop new reactions and processes and thus make new materials and improve the properties of older materials. The era of “shake and bake” in synthesis is behind us.

Aircraft engines represent one of the most extreme tests of materials. Backman and Williams discuss advanced materials for aircraft engines. Turbine disks and blades are among the most demanding applications. High temperature and stress can lead to fatigue, corrosion, oxidation, and erosion. Currently, superalloys can be used at temperatures greater than 1200°C. The future will bring new intermetallic and composite materials that will make even lighter weight, stronger, and safer materials possible.

At the other extreme of applications are electronic materials. Synthesis in this area requires a detailed understanding of the physics and chemistry involved in depositing extremely small amounts of matter in precise physical arrangements and locations. Metiu, Lu, and Zhang describe computer simulations of the kinetics of epitaxial growth and the formation of aggregates during deposition of atoms on semiconductor surfaces. A qualitative understanding can be gained of processes such as aluminum segregation during the growth of AlGaAs coherent tilted superlattices and formation of islands during the deposition of silicon on Si(100) surfaces. These simulations become even more relevant as new experimental techniques allow us to examine atomic “clusters” as they are formed.

Wiley and Kaner discuss rapid solid-state precursor synthesis. Solid-state reactions often require long reaction times at elevated temperatures, in part because of the limited intimate contact between solid reactants and long diffusion path lengths. Metathesis (exchange) pathways can be used to initiate extremely rapid reactions at or near room temperature. These methodologies can be used to control particle size and to make high-quality ionic solid solutions.

Nature is a wonderful source of materials, and there is much to learn from the structure of natural materials and the way in which they are made. For example, living systems construct structural ceramic composites from readily available materials. Heuer et al. describe materials-processing strategies based on biomimetic approaches. Mother-of-pearl, dentin, enamel, cartilage, bone, and eggshell are bioceramics synthesized under low-temperature aqueous conditions. We even use some of these, such as Portland cement, for our own structural purposes. The biosynthetic rates range from very slow to quite fast. We need to adopt the best of what nature has to offer.

Finally, Allcock describes rational design and synthesis of new polymeric materials. The interest here is in using polymers in hybrid materials which are designed at the interface of ceramics, metals, and electroactive or electro-optic materials. Many materials have intrinsic advantages that naturally lead to some corresponding disadvantage, for example, strength versus brittleness. Hybrid materials may help to overcome some of the problems in this area.

In these special issues that present broad overviews we can see an indication of how well we, as scientists, are doing in our respective areas. Materials science is particularly interesting because of the close coupling between basic knowledge and applications. It is easy to make the case that our investment in this activity is a good one, as is obviously true in many other fields. It is also true for areas that appear initially to have fewer applications. However, the articles in this issue show how strongly fields of science are coupled together and how basic research in one area impacts work in others. The dividends from support of science are spectacular and remain one of our best investments.—JOHN I. BRAUMAN
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line in figure 1 of (2). Chakraborty and Kidd refer to more than 2000 U.S. court cases that have employed DNA evidence [(2), reference 4]. This is misleading, as the majority areaternity cases in which the DNA types of mother, child, and putative father are usually available for comparison. Chakraborty and Kidd compare binning the variable number of tandem repeat (VNTR) sequences with the grouping of A1 and A2 blood type alleles. This comparison is inappropriate because the problem with binning VNTRs is not that alleles are grouped but that sometimes they are assigned to the wrong bin. Their statement that the “worst case” scenario is an equal mixture of Poles and Italians is incorrect—it is actually the best case for their argument. Their statement [(2), p. 1737] that the “arithmetic and underlying principles are identical” for linkage equilibrium and Hardy-Weinberg equilibrium is simply incorrect. In a quote from our article, they also did not include an important qualifier present in our original text [(2), reference 6].

Wills states in his letter that our arguments are based on “old” blood group data. Why Wills would disregard reliable blood group data is unclear, because even Chakraborty and Kidd concede their relevance. Wills also cites a high mutation rate among some VNTRs as the basis of a “mutational churning process” that is “a very large reason for the relative uniformity of allele frequencies from one human group to another...”. This hypothesis “explains” what has not yet been shown to exist, as relative uniformity of allele frequencies is precisely the point in dispute. We see no evidence of VNTR “churning” in French and Israelis or in the South American Indian tribes studied by Kidd et al. (6) [(1), p. 1749]. Wills also makes much of the observation that one of our subheadings (1) is identical to the title of a 1902 pamphlet by V. I. Lenin. This coincidence has no more relevance to DNA typing than the fact that Wills’ letter makes favorable reference to Japanese automobile companies.

Austad concedes the validity of our arguments, but points out that DNA typing is certainly better than polygraph results, so why all the fuss? His argument seems to be that new sources of scientific evidence should be held to a standard of reliability no greater than methods currently in use. We would make a fundamental distinction between the intrinsic limitations of a technology and limitations imposed by the use of false assumptions, particularly when simple alternatives are available. For example, although polygraph examinations have a high intrinsic error rate, we suppose that Austad would object to a test in which an electrical short in the machine produced additional erratic readings. Our view is that erroneous assumptions about genetic uniformity among ethnic groups are no more necessary to DNA typing than electrical shorts are necessary to polygraph machines.

We would finally like to emphasize that this dispute is not about the use of DNA evidence in the courtroom. DNA typing is a very powerful procedure. We regard it as “possibly the most powerful innovation in forensics since the development of fingerprinting in the last part of the 19th century” [(1), p. 1746]. All we ask is a basic degree of candor in reporting the statistical significance of a match. With databases as large as \( x = 10,000 \), why not use \( 1/e \) as a conservative estimate of the probability [(1), p. 1749]? After all, 0.0001 is already a pretty small number. Why invoke unsupported assumptions in order to obtain a still smaller probability that is exaggerated and unreliable? Perhaps it is because the organizations whose interests are served by numerical exaggeration have also been in charge of choosing the statistical procedures.

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REFERENCES


Erratum: In the abstract and in the text (line 35 in the middle column of page 185) of the report “Electrical resistivity and stoichiometry of K2Co9O14 films” by G. P. Kochanski et al. (10 Jan., p. 184), the minimum resistivity was given incorrectly as 2.2 microohm-cm. The correct value is 2.2 milliohm-cm.

Erratum: In the News & Comment article “Is homosexuality biological?” by Marcia Barinaga (30 Aug., p. 956), it was suggested incorrectly that the suprasomatic nucleus is not part of the hypothalamus.

Erratum: The Table of Contents for the issue of 31 January 1992 (p. 508) incorrectly listed a letter by J. Bello as appearing in the Letters section beginning on page 514. The letter appeared in the issue of 14 February on page 784.

Erratum: In figure 1 (p. 1509) of the Research Article “Radar images of Mars” by D. O. Muhleman et al. (27 Sept., p. 1508), the Mars longitude of the sub-Earth point was mislabeled in each of the six snapshot radar images of Mars. None of the labels should have contained a decimal point. The values of \( \lambda \) in the labels should have been 78, 92, 104, 120, 133, and 147, respectively.
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published. “Nicholls acts as though his hands were tied. I believe that the editor makes the final decision, and Nicholls abrogated his responsibility. There seem to be gross procedural errors here. We need an investigation to find out the process whereby this article got published to make sure this kind of thing doesn’t happen again.”

Zimmerman isn’t the only one who thinks further action is in order. Last fall, several Canadian professional organizations condemned publication of the article, including the Canadian Association of Physicians, the Women in Scholarship Committee of the Royal Society of Canada, and the Canadian Mathematical Society; others are scheduled to debate the issue this spring. In mid-January, a petition from the York community with 547 signatures was conveyed to the NRC requesting it to republish Volume 68:9 without Freeman’s article—a request Nicholls denounces as “Orwellian” and a recourse members of the NRC are reported to favor only in cases of fraud.

But the hubbub brewing around him hasn’t changed Gordon Freeman’s opinions. Far from being something he wants to put behind him, he says his paper is “probably the first article in a new era of sociology.” And he has continued to cite the article even after the journal’s apology—for example, in a letter published in the January 1992 issue of Physics in Canada. Nor has Freeman limited himself to the pages of scientific journals. He has promoted his views on working mothers on TV in Canada and on the radio throughout that country and the United States, as well as in an Ann Landers’ column. He describes his critics as shrill, pro-feminist, and probably married to working mothers.

Nicholls, meanwhile, argues that the protest against Freeman’s article is motivated by “political correctness.” He calls the “whole affair” a “most interesting and complex mixture of scientific publishing, political correctness, vulgar politics of protest, poor journalism, media manipulation, and government agency damage control.” “If C.P. Snow were still alive,” Nicholls concludes, “he could make a great novel out of all of this.”

Robert P. Crease

Engineering Academy Elects New Members

The National Academy of Engineering has elected 79 new members and seven foreign associates. Total U.S. membership is now 1628 and there are 136 foreign associates.

New U.S. members are:


Foreign Associates:

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"It disturbs me that so many of today's young people go into medicine for the money. In my time, the chance to play God was enough."

28 FEBRUARY 1992
able to follow most, if not all, of the discussion. In addition, many interesting side comments are made throughout the book. Finally, some useful appendices on spinors, quantization of constrained systems, and other basic topics are provided.

I have very few criticisms of the book, and only one worthy of mention. I would have benefitted from more discussion of the difficulties and pitfalls of the proposed approach to quantization, particularly via the loop variables approach. Specifically, since one does not expect to have an easy time giving an exact formulation of any nonlinear field theory (much less general relativity), it should be expected that severe difficulties will arise when one attempts to specify precisely the choice of Hilbert space and specify a consistent regularization scheme for the operators representing the observables of interest. There is barely any mention of these issues in the book, and certainly not sufficient discussion to convey a clear impression of the nature of the difficulties that ultimately would have to be confronted in order to convert the loop quantization approach into a rigorously defined theory.

In summary, this book is very successful in achieving its goal of giving a clear, up-to-date introduction to the approach to canonical quantum gravity pioneered by Ashtekar. It is essential reading not only for anyone who intends to do research on this approach but also for anyone at the level of an advanced graduate student or beyond who is interested in broadening his or her perspectives on the theory of quantum gravity.

ROBERT M. WALD
Enrico Fermi Institute and
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Chicago, IL 60637

Photosynthesis


With recent refinements in the techniques for the transformation of photosynthetic organisms it has become possible to interrupt or delete genes of choice and to introduce site-directed point mutations. Researchers are thus now in a position to probe the roles of individual subunits of the protein complexes that constitute the photosynthetic apparatus and to understand how individual amino acids contribute to the redox and kinetic properties of the constituent proteins.

Bogorad and Vasil in the chapters they have solicited for this volume attempt to provide the biochemical, functional, and molecular biological framework for appreciating some of the contributions that the transformation techniques as well as random mutagenesis have made to our understanding of photosynthesis. Though with one exception the chapters are concerned with oxygenic photosynthetic organisms, there are also references to the homologous polypeptides, enzymes, and pigment molecules present in the photosynthetic bacteria.

Three chapters, by Vermaas and Ikeuchi, Chitnis and Nelson, and Widger and Cromer, deal with the redox complexes of the oxygenic electron transport chain. That on photosystem II is the most detailed, with an extremely thorough discussion of primary and secondary electron transport function of the reaction center, integrating kinetic and structural information. The authors show an appreciation of recent controversies and give a critical reading of a vast array of information assembled in an intelligible manner. The chapter on photosystem I touches on a wide variety of topics of interest having to do with structure, regulation, and evolution. The chapter on the cytochrome $b_6/f$ complex is a useful comparative anatomy of this complex and its homologs, stressing structural similarities and topology.

The chapter by Jagendorf, McCarty, and Robertson is a delight to read, containing an equilibrated balance of functional, structural, and genetic information on ATPase-ATP synthase from higher plants, cyanobacteria, mitochondria, and bacteria. This chapter brings together in a complementary fashion information on mutants, cross-linking, and chemical modification, enabling the reader to appreciate the discussion of opposing models of ATPase function.

The chapter by Bryant on cyanobacterial phycobilisomes is among the most detailed, with emphasis on the gross structure, roles, stoichiometry, and location of individual subunits. It includes an extensive discussion of operon structure and the consequences of interposon mutagenesis, of which the author is one of the prime practitioners. This chapter is so thorough that that by Tandeau de Marsac on chromatic adaptation, itself a thorough effort on light control of differentiation and pigment gene expression, inevitably retreats some of the same ground.

Another chapter on light regulation, this time in chloroplasts by Link, is well written, with a good introduction to control sites for gene expression in plastids and an emphasis on chloroplast differentiation in C4 plants. Another form of plastid differentiation to amyloplasts and chromoplasts is described in an interesting chapter by Kobayashi.

Two general chapters on oxygenic and anoxygenic photosynthesis are included. In trying to touch on many aspects at once these somewhat sacrifice depth and coherence and contain some errors. Chlorophyll and carotenoid biosynthesis, Rubisco assembly, and nuclear-plastid interactions are also represented in separate chapters.

A listing of chloroplast protein-coding genes toward the end of the book is useful for referencing sequences but could have been improved by identification of the gene products. The subject index is not very useful, and the book lacks an author index. However, the bibliographies associated with each chapter are for the most part extensive and current through 1989 and include titles of papers.

This volume brings together a diverse sampling of the photosynthetic world. Some recent work on site-directed mutagenesis of the reaction centers and cytochrome $b_1$ complex of the purple non-sulfur photosynthetic bacteria, much of it illustrative of the power of molecular biology for the probing of function, would have been a welcome addition. Also unrepresented is much fine recent work on transport of proteins into the chloroplast and thylakoid. But the topics that are represented receive for the most part thorough treatment, and the reader is directed to reviews that fill the gaps. Those interested in the topics covered will undoubtedly find themselves enlightened, whether they be neophytes or more mature photosynthesizers.

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