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Collage of domain shapes and patterns. The foreground figure illustrates a magnetic field–induced branching instability of a droplet in a thin layer of ferrofluid. The color gradient illustrates the evolution of the droplet’s shape, and contours of successive intermediate states are superimposed. The background shows an ordered “bubble” domain pattern, recorded in a thin magnetic garnet film in the presence of a small magnetic field. See page 476. [Illustration: M. Seul and S. Cullerton. Foreground adapted from computer simulations of D. P. Jackson, R. E. Goldstein, and A. O. Cebers]

REPORTS

Arches and Clumps in the Uranian λ Ring 490
M. R. Showalter

Energy Dependence of Abstractive Versus Dissociative Chemisorption of Fluorine 493
Molecules on the Silicon (111)-(7×7) Surface
J. A. Jensen, C. Yan, A. C. Kummel

Absorption of Solar Radiation by Clouds: Observations Versus Models 496

Warm Pool Heat Budget and Shortwave Cloud Forcing: A Missing Physics? 499

Clustering and Periodic Recurrence of Microearthquakes on the San Andreas Fault at Parkfield, California 503
R. M. Nadeau, W. Foxall, T. V. McEvilly

Mechanisms of Magma Generation Beneath Hawaii and Mid-Ocean Ridges: Uranium/Thorium and Samarium/Neodymium Isotopic Evidence 508
K. W. Sims, D. J. DePaolo, M. T. Murrell, W. S. Baldridge, S. J. Goldstein, D. A. Cagle

Structural Basis for Sugar Translocation Through Maltoporin Channels at 3.1 Å Resolution 512
T. Schirmer, T. A. Keller, Y.-F. Wang, J. P. Rosenbusch

Phosphorylation Without ZAP-70 515
Activation Induced by TCR Antagonists or Partial Agonists

Cytostatic Gene Therapy for Vascular 518
Proliferative Disorders with a Constitutively Active Form of the Retinoblastoma Gene Product

Molecular Basis of the cauliflower Phenotype in Arabidopsis 522
S. A. Kempin, B. Savidge, M. F. Yanofsky

Mutations of Keratinocyte Transglutaminase in Lamellar Ichthyosis
M. Huber, I. Rettler, K. Bernasconi, E. Frenk, S. P. M. Lavrijsten, M. Ponec, A. Bon, S. Lautenschlager, D. F. Schorderet, D. Hohl

Sex Differences in Regional Cerebral Glucose Metabolism During a Resting State
R. C. Gur, L. H. Mozley, P. D. Mozley, S. M. Resnick, J. S. Karp, A. Alavi, S. E. Arnold, R. E. Gur

Cloning of an Intrinsic Human TFII D Subunit That Interacts with Multiple Transcriptional Activators
C.-M. Chiang and R. G. Roeder

Paleotopography of Glacial-Age Ice Sheets 536
R. L. Edwards; W. R. Peltier

T12 Downregulation of Macrophage 538
HIV-1 Replication
L. J. Montaner and S. Gordon; S. Romagnani and E. Maggi

503
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Science and Technology Policy

Scientists and engineers in academia and elsewhere are encountering changing policies that can profoundly affect their careers. Effects of the end of the Cold War continue to be manifest. The squeeze on federal discretionary funds is likely to be tightened. Enforcement of the Government Performance and Results Act of 1993 (Science, 6 January, page 20) could have important consequences.

The 37 chapters of a well-edited, recently published AAAS book* describe much of what happened affecting science and technology policy up to and including 1994. It portrays contrasting opinions of many policy-makers. Authors include President Clinton, Vice President Gore, and Democratic Congress people. Experts from academia, industry, and think tanks also participated. None of the current Republican leadership were authors, but there is little indication that their attitudes differ decisively from those of the Democrats. Their future budget cutting could badly damage research and development institutions.

In the federal government, there are many unneeded, invisible bureaucrats. If the Government Performance and Results Act is appropriately administered, they will be identified. But both the National Institutes of Health and the National Science Foundation have often been in the spotlight, and they are not in need of detailed congressional command and control. However, the NIH and NSF now find it necessary to begin to formulate results-oriented criteria for awarding grants. The NSF has begun to develop goals for its science and technology centers at universities. One of the proposed criteria on which centers would be judged would be that “nearly all graduates” become “outstanding contributors” to the workforce. Grant funds are often used to pay stipends of graduate students. In the past, some faculties have indoctrinated them in the view that the only respectable career was that of a tenure professor. Now, faculties should consider how better to prepare students and help them to find distinguished work outside of the campus.

Research in the physical sciences has led to enormous societal benefits. Prospects are good that exploratory (basic) research in chemistry, condensed matter physics, and materials science will lead to important commercial applications. If basic research in the physical and biological sciences is curtailed, the United States will find itself outdistanced by more vigorous competition. At present, the United States is competing fairly well in high-technology products. However, Pacific Rim countries are achieving competence in high technology, and governments are supportive of industrial initiatives. Economies and exports are growing rapidly. In the United States, politicians have repeatedly announced goals of high paying jobs and global competitiveness. There has been more talk than useful action.

When contemplating options and legislation, politicians should be aware of the attitude of the Industrial Research Institute. Members of this institute come from companies that create a very large fraction of high technology products. The institute has stated that a principal product it wishes from universities is well-trained people. Young graduates can bring with them information and skills arising from the latest developments in science and technology. However, they can do so only if they have been trained where world-class research is being conducted.

As a result of the restructuring of many companies, the levels of their efforts in basic research have been attenuated. Their dependence on university research has increased. Industry has expanded its support of university research and entered into many hundreds of collaborative arrangements. About 35 percent of all U.S. patents issued to industry have arisen from collaborations between basic scientists working in universities and industrial scientists working in their laboratories.

The United States has been a world leader in basic research. Knowledge has been quickly transferred to industry by graduates, faculty consultants, and others. Why are so many breakthroughs made in the United States commercialized in other countries? Many reasons have been put forth. Poor leadership in industry, Wall Street, and a national lack of savings have been blamed. But what about government? Is it not time for the politicians to do some soul-searching? How do the rules of the game in the United States hinder innovation?

Philip H. Abelson

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Wagnerian Genetics

The recent report of an “Abnormal fear response and aggressive behavior in mutant mice deficient for α-calcium calmodulin kinase II” by Chong Chen et al. (14 Oct., p. 291) provides what may be an unusual insight into the presumably inherited deficiency manifested by a certain Siegfried Volsung. While his entire pedigree has long been open to speculation, it is asserted that he was the offspring of the consanguineous mating between brother (Siegmund Volsung) and sister (Sieglinde Neidung, née Volsung), who were separated at birth, only to reunite in early adulthood (R. Wagner, Die Walküre, Act I). Although Mendelian genetics was awaiting rediscovery at the time this kindred became the subject of a lengthy report (Der Ring des Nibelungen, 1876), such laws of inheritance would predict that Siegfried was significantly at risk for genetic disorders. Indeed, it is a wonder that the only phenotypic evidence of consanguineous parentage was a complete lack of fear. In a manner somewhat comparable to the α-CaMKII–deficient mice described by Chen et al., Volsung was also disposed to remarkable acts of defensive aggression and risk-taking behavior [for example, Siegfried versus Fafner (Siegfried, Act II)].

While genetic counseling was not generally available to the community in which he lived, Siegfried is unlikely to have heeded prudent advice, in typical fashion, he fearlessly won the affection of his aunt Brunnhilde (Siegfried, Act III). Because the murine machismo reported by Chen et al. clearly demonstrates a dominant inheritance pattern, one must scrutinize the behavioral phenotypes of Siegfried’s parents for evidence of intermediate forms of fearlessness. And, in fact, usual precaution is not a feature of their daring escape from Sieglinde’s oppressive domestic trappings while at the same time singing constantly at great volume in the middle of the night (Die Walküre, Act I). The first and second filial offspring of the inevitable proband-aunt (Siegfried-Brunnhilde) mating may have provided valuable insight into the penetrance and mode of inheritance in this unusual disorder; however this will never be known because a complicated family dispute ended in not only Siegfried’s death but the immolation of all known inhabitants of the region (Götterdämmerung, Act III, final scene).

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Response: We appreciate that Vogel brings to our attention the fascinating story of Siegfried Volsung, as depicted in Wagner’s opera Der Ring des Nibelungen. Our previous work has shown that an autosomal dominant mutation in the α-CaMKII gene is associated with a phenotype of increased defensive aggression and a lack of fear. In contrast, the neuropsychiatric condition exhibited by Siegfried, whose parents are brother and sister, seems to be derived from an autosomal recessive mutation. Thus, it is not clear at all whether there is any genetic parallelism between the α-CaMKII heterozygous knockout mouse and the man. There are, of course, other possible interpretations. For example, Siegfried may have carried a sporadic mutation in the α-CaMKII gene; or one of his parents may have had heterozygous or homozygous mutation in the α-CaMKII gene. Siegfried’s father, Siegmund, appears to share similar traits. As Bernard Shaw has characterized [The Perfect Wagnerite: A Commentary on the Ring of the Nibelungs (Constable, London, 1956)], “The boy Siegfried inherits . . . all his father’s hardihood. The fear against which Siegmund set his face like flint, and the woe which he wore down, are unknown to the son . . . ” If Siegfried’s mother, Sieglinde, is normal, both the father and the son may have had the heterozygous mutation. In this case, the genetic parallelism may be justifiable.

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Teaching Engineers and Scientists

The Policy Forum by Mary Lowe Good and Neal F. Lane “Producing the finest scientists and engineers for the 21st century” (4 Nov., p. 741) contains little that is either new or provocative. It reads like a sermon based on the gospel according to the Office of Science and Technology Policy and the National Science Foundation,
chiefly the “Platitudes.” Good and Lane recommend that (i) “teaching and learning must be reinvigorated as the primary mission of academic institutions,” (ii) federal policies should support education and training of scientists and engineers, and (iii) graduate education must reflect changes in the economy and in the labor market for these professionals.

Those who have been teaching and doing research for the past 30 years have witnessed a startling expansion and contraction of federal support for science and engineering coinciding with the beginning and end of the Cold War. Most faculty members have reflected upon the meaning of these changes both for society and for their own careers and those of their students. They are well aware that science and engineering education will have to respond to new challenges. They do not need to be told that teaching is important, that they had better start doing research of interest to industry, and that “promising and largely unexplored opportunities may reside in the small business sector.” Many have already found how difficult and time-consuming it is to develop cooperative research with companies while maintaining a regular load of teaching and advising.

Problems mentioned elsewhere in the “Innovations on Campus” issue—cutbacks in research funding, scarcity of jobs for Ph.D.’s, and the decreasing numbers of undergraduates with interest in and adequate preparation for these fields—will not be solved by “innovative” teaching. It is not yet clear that smaller graduate populations will lead to an increase in quality because there may be a tendency for universities, especially high-tuition private institutions, to continue to accept poorly prepared students so as to survive, and then try to turn teaching into entertainment for the “MTV generation.”

It is hard to be as optimistic as Good and Lane about the prospects for university science and engineering in the late 1990s and early 2000s. Daniel E. Koshland Jr.’s editorial in the same issue (“Educating the best and employing them,” p. 711) suggests that he has a more realistic view of the future—there will fewer Ph.D. programs, and the emphasis will be on educating the “most interested and the most able” graduate students for a limited number of research and teaching positions. Many universities will not be able to maintain viable graduate programs and will return mainly to undergraduate teaching. This will not be a bad thing if they insist that those who graduate, those with a B.S. or B.A., have a sound understanding of basic scientific and engineering principles together with a better appreciation of society’s needs and the ability and willingness to work with other citizens for the common good.

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Koshland’s editorial and Good and Lane’s Policy Forum point to the importance of maintaining the strength of Ph.D. research while increasing the contribution of academia to the evolving research needs of modern industry. The industrial Ph.D. program that the Northeastern University Physics Department tried to create in the early 1970s may be a model of a low-risk contribution toward that goal.

We proposed the following plan: (i) Students who had passed the department’s qualifying examination and all the required course work would be eligible for consideration as Ph.D. candidates. (ii) A thesis committee would be set up by the departmental graduate committee that would include a person in industry who
would supervise the student. (iii) A student’s work would be published and non-proprietary. Patents based on the research would have to follow university and National Science Foundation (NSF) policies and would in no way be allowed to interfere with publication. (iv) A student would be supported by the program as a university graduate research assistant. While the stipend was to be the standard one in the department, travel or “off site” costs would be allowed. Funding of the program was to come from the NSF, but it was expected that companies would want to make donations to the grant independent of any specific thesis project. (v) People from industry emphasized the need to distinguish thesis research from regular in-house research. There were pure physics problems that they wanted to see addressed and for which companies could not justify the cost.) For such basic research, companies would supply the environment, equipment, and adviser’s time. Industrial proprietary research would be conducted by employees without interference from outsiders. (vi) Because of all the matching requirements for each individual case, the program would start off very slowly and only gradually build up to its full potential.

One of the benefits industry expected from this program was to develop candidates for future regular employment; another was to forge ties with the faculty. A requirement that participants had to be university students rather than company employees distinguished our program from many others. Our industrial partners were concerned that the long-term and basic research needs of industry not be sacrificed to expediency.

The department and about a dozen industrial concerns agreed completely on how the program should work. The NSF, however, was not interested, and as the plan depended on NSF funding, it could not be implemented. Now that a different wind is blowing in Washington, D.C., we hope that the NSF, at least, may wish to experiment with such a program. It is much better to let people in front-line industries propose basic research topics based on deficiencies they have seen than to have government tell them what research is needed.

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Good and Lane make several useful points. However, they also make a typical omission, that of not considering scientists and engineers who develop an interest in academia later in their careers. After 20 to 25 years of practical experience in industry or consulting, some entertain the possibility of transferring their knowledge to students. However, this opportunity is largely closed because of the academic requirement for a doctorate, which is neither a prerequisite nor an advantage in many industrial or consultant positions. As a result, the abilities of these career scientists and engineers (their practical experience, understanding of pragmatic needs, perspective on career path opportunities, and knowledge of marketplace) are being lost. Many of these people have managed field and study programs in the hundreds of thousands or millions of dollars, know how to market industry for funding (and have the appropriate contacts to do so), have adjunct teaching experience, and have a history of mentoring young staff. But until job requirements for professors are altered, this valuable resource will go unused, and educational deficiencies will continue.

Stuart J. Spiegel
O’Brien & Gere Engineers, Inc.,
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Uppsala (pronounced UOP-SA-LA) is a university town about 45 minutes by car from Stockholm, Sweden. The university here was founded in 1477 and has a lengthy tradition of developing exceptional life science researchers. (The great Carl von Linne and Anders Celsius both lived and worked in Uppsala.)

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Protection Against Cholera

Early Indian medical literature describes clinical features of patients with a disease similar to cholera (1). Since then, there have been many worldwide pandemics (involving Europe and North America) of cholera, most of them originating from the Indian subcontinent. However, the incidence of the cystic fibrosis (CF) gene among Asians is extraordinarily low (2), which does not appear to be compatible with the hypothesis that this gene has a protective effect against cholera (S. E. Gabriel et al., Reports, 7 Oct., p. 107). Genetic traits that offer protection against infectious diseases have been shown to be high among populations where the disease is endemic. The prevalence of the sickle cell gene, for example, hypothesized to confer some immuno- lusability to falciparum malaria, parallels the geographic distribution of this disease.

Although the finding that mice which do not express the CF transmembrane conductance regulator protein were protected from the effects of cholera toxin is significant, it is not clear how that relates to the high incidence of the CF gene observed among Caucasians.

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References

Response: Fontelo raises an interesting question. Although it is clear that cholera was and remains a major cause of mortality in the Indian subcontinent, it is also of historical importance in the Northern European population. We used cholera toxin in this study because it is the archetypal enterotoxin causing secretory diarrhea and the mechanism of action is well defined. However, we had also suggested that other bacterial toxins, including Escherichia coli STa and LT, which may have been more prevalent in the Caucasian population, could have had similar protective effects, because the rate-limiting step for secretion of the CF transmembrane conductance regulator (CFTR). Regrettably, this information was deleted because of an editorial decision to shorten the manuscript. Clearly any potential heterozygote advantage is only of importance in a population expressing the disease at a high incidence. Therefore, correlation for a CF heterozygote is only relevant in the Caucasian population. Speculation regarding the absence of such a complex effect such as a balanced polymorphism (or selective heterozygote advantage) in one population versus another is considerably beyond the scope of our study. Differences between population CF frequencies may actually reflect more on the genetics of CF than on the ability of cholera to increase the population frequency. Most important, our data demonstrate the molecular and functional differences between CFTR(-/-), CFTR(+/-), and CFTR(+/+) mice in response to toxin. Resistance against cholera or other bacterial enterotoxins may have been a selective pressure for the high frequency of the human CF heterozygote, but a large human epidemiological study would be required to ultimately address that issue.

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Mo_nC_4n Cluster Synthesis: Clarification

In our report “Synthesis and characterization of molybdenum carbide clusters Mo_nC_4n (n = 1 to 4)” (7 Jan., p. 68) (1), we found negative ion mass spectral evidence for Mo_nC_4n species produced by XeCl laser photolysis of Mo(CO)_6. The molecular stoichiometry of this new molybdenum carbide was proposed on the basis of observations of negative ion masses and their corresponding isotope abundances, fragmentation information, ion-molecule reactions, and elemental analysis.

Previous work had indicated that the ultrafine particles generated by laser photolysis of Mo(CO)_6 consisted primarily of molybdenum and carbon (2). We examined the solid with glow discharge mass spectrometry, which yielded an elemental composition of 51.8% carbon, 46.1% molybdenum, 1.6% iron, and 0.29% oxygen and a molar stoichiometry similar to that of MoC. These data appeared to support the mass spectral measurements of Mo_nC_4n and indicated that the black solid was mainly molybdenum and carbon with only a trace of oxygen.

Subsequent to these studies, Kenneth Suslick and Taeghwan Hyeon (3) obtained very similar laser desorption negative ion mass spectra from a sample of MoC (an observation that we had also made previously). D. Cox (4) has pointed out to us that most samples of MoC contain a small amount of molybdenum oxide (as verified by Raman spectroscopy). Because molybdenum oxide has a relatively large electron density, it could enhance the formation of negative ions and account for the appearance of Mo_nC_4n mass spectra.
denumoxide pure molybdenum oxide exhibits calibration trace affinity these served for result observed num with enhanced verify rather than cy ion mass spectrums similar to ionmassspectrums that the remaining 5% of the samples correspond to Mo₃(O₂)₇⁻ instead of Mo₃(C₄)₇⁻. For the remaining 5% of the samples, the masses appear to more closely match the molybdenum carbide clusters, although better mass calibration experiments are being done to verify this result. A complete study of the laser photolysis of Mo(CO)₆ should resolve these issues.

C. Jin
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References
4. D. Cox, personal communication.

Corrections and Clarifications
The Research News article, “Oncogenes reach a milestone” by Jean Marx (23 Dec., p. 1942), incorrectly stated that Ray Erickson did his pioneering work on the src gene at the University of Colorado at Boulder. He was instead at the University of Colorado Health Sciences Center in Denver.

The photograph on page 1415 accompanying the book review of Luna B. Leopold’s A View of the River by Vic Baker (25 Nov., p. 1414) showed meanders of the East Fork River near Boulder, Wyoming, not the Popo Agie River.

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along the way to foraging ecology, sex ratio evolution, migration, and the evolutionary consequences of geographic variation. In fact, the only major questions in evolution it does not address are why sex exists (presumably because swallows are not parthenogenetic) and the evolution of sterile castes and eusociality (because swallows are not cooperative breeders).

Swallows are abundant and relatively easy to observe and have a sexually dimorphic trait that is amenable to experimental manipulation: the forked tail, which is on average 17 percent longer in males than females in the Danish population Møller studies. With an ingenious combination of field experiments and painstaking observation, Møller looks not only at the immediate consequences to males of having a longer tail, namely higher mating success, but also at the long-term outcome of female preference. More ornamented males are more likely to copulate with females in addition to their mates; they and their offspring live longer and have fewer parasites than shorter-tailed males; and their mates tend to invest more in the offspring than do the mates of shorter-tailed birds. Some of these attributes appear to be genetic, as demonstrated by elegant cross-fostering experiments, whereas others can be emulated through the use of birds with artificially extended tails. With all of these advantages, you might ask, why don’t all males have long tails and, for that matter, why isn’t the tail itself even longer? Møller anticipates these questions with a chapter discussing the constraints on ornament evolution. Long tails are costly to produce and maintain, and only high-quality males can display them. Females choosing a long-tailed male can therefore expect to have high-quality offspring, but the difficulty of flying with such an unwieldy extension probably places an upper limit to tail length in these aerial acrobats.

These findings are always carefully generalized to animals other than barn swallows, which is why this book is not simply a narrow study of a single species. Møller displays a remarkable opportunism in his research, losing no chance to turn the smallest piece of information into a test of a hypothesis. For example, over the course of five field seasons lasting from six weeks to four months, he found 69 roadkill juvenile swallows. Most researchers would have passed them by; after all, that’s less than one dead bird per week, not much of a sample size. Møller, however, took advantage of the birds’ deaths to determine their sex via dissection of the gonads, male and female juveniles not being morphologically distinct, and used the information to look for bias in the secondary sex ratio. This dedication to detail is combined with a thorough grounding in theory throughout the book.

The book is not without its drawbacks. The writing style is terse and dry, albeit clear. It is sometimes difficult to tell when assertions are supported by data and when they are merely suppositions. The literature citations on sexual selection in other birds are rather scanty, especially with regard to empirical studies; this adds to the impression of a book about sexual selection that happened to use barn swallows as examples, but could leave the reader with the erroneous conclusion that little else has been done. Of course, as one of the most prolific authors in evolution and ecology today (12 single-authored publications cited for 1991 alone), Møller has ample scope for using his own work.

Like many others who study sexual selection, Møller focuses almost exclusively on males; chapter titles include “Male mating advantages,” “Options for unmated males,” and “Paternal care and male ornamentation,” with no corresponding attention to females. This bias, though understandable because of the conspicuousness of the male ornament, nonetheless neglects the other key player in the sexual selection process. Some recent work in the field has attempted to redress this omission, and it is too bad more of the book is not directed toward that aim.

Perhaps some of the biologists using Dro sophila or Caenorhabditis elegans in their research might consider a shift toward the graceful and utilitarian subject of this book; Møller has demonstrated an ample payoff from his attentions.

Marlene Zuk
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Galaxies are of course the island universes within which reside most of the stars, much of the gas, and a little of the mass in the cosmos. Activity in Galaxies, like that in animals, is defined by the metabolic rate. When this is well above the average “resting” (aka. basal) level, a galaxy or animal is said to be active. For an animal of mass \( m \) kg, the mass-specific basal metabolic rate is about \( m^{-1/4} \) cal s\(^{-1}\) kg\(^{-1}\). . . . For galaxies, the mass-specific basal metabolic rate seems not to be mass strongly dependent, and is about 0.1 – 1 L. M.\(^{-1}\) (5 \( \times 10^{-6} \) – 5 \( \times 10^{-5} \) cal s\(^{-1}\) kg\(^{-1}\); 1 L., M.\(^{-1}\) is the average rate of energy release per unit mass of cosmic baryons which fuse 10% of their hydrogen in a Hubble time). Animal athletes, such as horses running the Kentucky Derby, can reach metabolic rates 20 times their basal rate. Galaxy athletes like quasars and extreme star bursts are even more impressive, reaching \( \geq 10^8 \) times their basal rates (\( \geq 10^6 \) times in selected regions).

—E. S. Phinney, in Mass-Transfer Induced Activity in Galaxies
(Isaac Shlosman, Ed.; Cambridge University Press)

Books Received


**Conformational Theory of Large Molecules.** The Rotational Isomeric State Model in Macromolecular Systems. Wayne L. Mattice and Ulrich W. Suter, Wiley, New York, 1994. xvi, 448 pp., illus. $54.95.


Dictionary of Cyanotoxins. Horst Ibelings. VCH, New York, 1994. xii, 778 pp., illus. $110 or DM 184 or £74.


Handbook of Geostatistical Orbitals. E. M. Soop, Kluser, Norwell, MA and Microcosm, Torrance, CA, 1995. vi, 309 pp., illus. $94 or £60 or Dfl. 150. Space Technology Library, vol. 3.


Laboratory and Scientific Computing. A Strategic


Methods in Membrane and Transporter Research. Edited by James L. Land, Georgetown, TX, 1994 (distributed, CRC Press, Boca Raton, FL), xii, 127 pp., illus. $89.95. Molecular Biology Instruments, 19.


The Variability of Large Alluvial Rivers. Stanley A. Schumm and Brian R. Winkley. Eds. ASCE Press, New York, 1994. ix, 467 pp., illus. $44.


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