academic physicists, provoking laments from seasoned hands, such as Merle Tuve, who observed in 1959 that "a professor's life nowadays is a rat race of busyness and activity, managing contracts and projects, guiding teams of assistants, and bossing crews of technicians, plus the distractions of numerous trips and committees for government agencies, necessary to keep the whole frenetic business from collapse" (p. 196f.). Military patronage also affected the direction of research. The intensity with which many fields—for example, solid-state physics and quantum electronics—have been cultivated has depended much more on their perceived relevance to service missions than on their prospects of contributing to fundamental understanding.

Besides influencing the physicists' lifestyle and interests, military patronage has profoundly shaped the character of the knowledge they have sought and produced. This is likely to be the most controversial part of Forman's paper. Yet the case that he builds is strong. He has no trouble adducing evidence that, just as the military funding agencies wanted, physicists have substituted a preoccupation with novel and refined technique for their former concern with new understanding. This instrumentalism, he believes, has permeated the entire discipline. It is manifest not only in such mundane areas as nuclear, atomic, molecular, and solid-state physics but also in elementary particle physics. Here Forman invokes recent studies by Sylvan Schweber and Andy Pickering to argue that the triumph of phenomenological theories "reflected both a general militarization of the social purposes of physics in the U.S., and a particular mental posture fostered by the application of brain-grease to military matters" (p. 223). He might also have invoked Hoddeson's study of Fermilab's development of the energy doubler. Forman concludes that American physicists have been self-indulgent to think that they have been using the military. Quite the contrary, it is the military that has used them.

Does the perspective developed by Forman apply to the whole of postwar science? It would surely need major modification for those disciplines such as the biological sciences where military patronage is small. It might need modification as well for mathematics and astronomy, two disciplines that have received substantial funding from the military. Still, Forman's trenchant analysis sets a direction for historians of recent American science. No doubt studies examining the validity and applicability of his argument will soon be forthcoming.

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Limits on Adaptation

Genetic Constraints on Adaptive Evolution. VOLKER LOESCHCKE, Ed. Springer-Verlag, New York, 1987. x, 188 pp., illus. $49.50. Based on a symposium, Syracuse, NY, Aug. 1986.

With the decline of the pan-adaptationist view in evolutionary biology, the search has begun for the demons that prevent populations from reaching evolutionary nirvana. If adaptation had its way, every individual would mature instantly, reproduce at an infinite rate, and live forever. No organism meets these criteria, and this motivates the search for the constraints that frustrate adaptation. A logical place to look for those constraints is at the genetic level because selection cannot produce evolutionary change if appropriate forms of genetic variation are lacking. This reasoning is leading a growing number of workers from fields as diverse as genetics, development, morphology, and ecology to examine how patterns of genetic variation limit adaptive evolution. Nine papers on this topic from a symposium of the International Congress of Ecology in 1986 are brought together in this volume. Though interesting insights emerge from some chapters, the book falls short of presenting a synthetic overview of its subject.

Life history characters provide particularly compelling examples of constraints because finite reproductive output and senescence are so clearly maladaptive. Rose, Service, and Hutchinson review the evidence regarding the sources of genetic constraints on life histories in the book's most interesting (and amusing) chapter. Their own work on *Drosophila* shows how constraints can be analyzed with the classical methods of quantitative genetics. The topic of life history evolution is picked up in other papers by Barker and Thomas, by Clark, and by Christiansen. Several of these papers focus on the possibility that the joint action of pleiotropic mutation and selection might determine the genetic correlations that define the constraints. Unfortunately, the theory to which the authors appeal is based on the assumption of weak stabilizing selection and is inappropriate for traits such as life history characters that are under strong directional selection. Little is known either empirically or theoretically about the structure of genetic correlations under these conditions, a lacuna that is one of the outstanding problems in our understanding of the sources of evolutionary constraints.

A theme that recurs in several chapters is the importance of phenotypic plasticity (or reaction norms), the developmental and physiological responses of genotypes to environmental variation. Via's chapter, which discusses implications of phenotypic plasticity using quantitative genetic models, is perhaps the best introduction to this topic available anywhere. Van Noordwijk and Gebhardt discuss the evolutionary consequences of continuous forms of environmental variation, and Scharloo reviews the genetics of developmental buffering against environmental and genetic variation. Schaal and Leverich discuss phenotypic plasticity and other phenomena important in plant populations. A molecular perspective is introduced by Golding, who shows that certain DNA sequences bias the frequency of different classes of mutations.

Despite its high points, the book is disappointing as a whole. Several important approaches to the problem are missing entirely from it. The comparative method, for example, is the only way to study changes in patterns of genetic variation over substantial periods of evolutionary time. Measurements of selection in natural populations can identify characters that are under directional selection but that are prevented from evolving by genetic constraints. Developmental biology is critical in revealing the mechanisms by which genetic constraints are expressed and has been prominent in emphasizing their importance in evolution. These and other approaches receive no attention, whereas quantitative genetics is represented by six of the nine chapters. The book thus presents a somewhat narrow view of an important subject.

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Early Precambrian Terrains

Evolution of the Lewisian and Comparable Precambrian High Grade Terrains. R. G. PARK and J. TARNEY, Eds. Published for the Geological Society by Blackwell Scientific, Palo Alto, CA, 1987. viii, 315 pp., illus. $80. Geological Society Special Publication no. 27. From a conference, Leicester, U.K., March 1985.

This book, the proceedings of the third Lewisian conference, replaces the proceedings of the second, 1971, conference. The editors, J. Sutton, and the late J. V. Watson contribute, together with a host of researchers who had probably never heard of the Lewisian in 1971. Besides the 18 papers on the Lewisian, there are 3 on Greenland and 1 each on Western Australia (Yilgarn), Enderby Land, and northeastern China.

The volume is dedicated to Watson and opens with an appreciation of her work,

noting that her untimely death almost coincided with the conference. The succeeding paper, by Sutton and Watson ("Questions for the future"), is a brief exposition of the history of research on the Lewisian complex and a sentient consideration of the problems posed by the Lewisian in the context of continental structure and growth. Two review papers follow, Park and Tarney on the Lewisian as a whole, with emphasis on the mainland, and Fettes and Mendum on the Outer Hebrides. In addition to discussion, the former presents new cross sections illustrating mainland Lewisian history, and the latter gives the first modern review of the Outer Hebrides and provides an excellent summary of recent research.

Next is a group of papers on the origin of granulites. First, the problem of the origin of the extreme depletion of large-ion lithophile elements of the granulites is considered, with an emphasis on models that involve depletion at a primary magmatic stage. Next, the adjacent amphibolite facies gneisses of the Gruinard district are treated in detail, and new data are presented. Three theoretical and observational papers on the granulite facies metamorphism complete the group; estimates of peak pressure and temperature vary about 20 percent.

A series of more specific papers follows, first on the geochemistry of marbles (one paper) and then on structural matters, mostly connected with Proterozoic shear zones (five papers). The next three papers, on geophysical matters, form a welcome addition to Lewisian studies; they discuss physical properties of the gneisses, crustal seismic reflection profiling, and paleomagnetism. The Lewisian section ends with a detailed discussion of the deep-seated Proterozoic dyke swarm.

The final group of papers are valuable comparative studies; the reviews of the Yilgarn Block and of the high-pressure granulites of Enderby Land are particularly instructive.

Altogether there is a wealth of information in this volume on the "high grade terrains" of the title. It is not, however, a textbook; the papers are not fully informative to the nonexpert on several major matters, notably the gray gneisses (the Laxford complex) and their relationship to the granulites. The "evolution" of the title is not accompanied by new geochronology or new insights into old geochronology; there is no systematic discussion of isotopic tracers except in the papers co-authored by Tarney. There still seem to be terminological problems; time is rather naively treated on occasion, and some rewriting of history may be noticed. Nevertheless, this book does justice to its famous subject: most of the many hundreds of papers on this 5000 square kilometers are included in the reference lists. It will be a very useful addition to library resources on crustal structure for the next decade, and then a fourth Lewisian conference will be required.

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Model Landforms

Experimental Fluvial Geomorphology. STANLEY A. SCHUMM, M. PAUL MOSLEY, and WILLIAM E. WEAVER. Wiley-Interscience, New York, 1987. xiv, 413 pp., illus. $49.95.

Nearly two decades ago, Judge R. H. Kroninger, in ruling on the effects of logging in a California watershed, noted that numerous expert witnesses in geology and engineering presented conclusions that were "hopelessly irreconcilable on such critical questions as how much and how far solid particles will be moved by any given flow of surface water." The witnesses "were able to agree only that sediment will not be transported upstream" (*State of California, Marin County*, v. *E. Righetti* et al., 1969). To students of rivers the words sting even today. For however hyperbolized the ruling may have been, it reminds us of a painful truth: we still do not fully understand complex, nonlinear fluvial systems with their internal thresholds and their evolutions that span geologic time.

Our excuses seem legitimate. The fluvial system consists of hundreds of major components in its drainage basins, conveyance channels, and alluvial fans or deltas and certainly many times that number of feedback loops. Like all good reductionists we have studied the subsystems, often to good effect, but are at a loss when we try to put the system back together. Those who have traditionally attempted to understand the whole system, primarily field geomorphologists interested in landscape evolution, have been confounded by incomplete records of fluvial responses to perturbations, or by superposition of responses, and have never traced a signal—say, a wave of erosion due to base-level lowering—throughout a natural river to its headwaters.

It is joyful news, then, when a book is born into a discipline so desperately in need of answers. Here under one cover are the products of 18 years of experimental investigations into the fluvial system by the arch-druid of the technique and his students. The experimental apparatuses employed are the rainfall-erosion facility (REF), a 138-square-meter sandbox with overhead sprinklers, and two tilting flumes. A typical REF experiment involves establishing a planar, sloping sand surface that is subject to some intensity of simulated rainfall from the sprinklers and documenting the evolution of the drainage net, the water and sediment yields, and so on. A typical flume experiment entails establishing a narrow ditch through the bed material and documenting the evolution of the channel pattern and sediment discharge, subject to various initial and boundary conditions. The objective of the experiments always is to "provide an insight into landform evolution and dynamics," not to provide quantitative predictions, because the models are not dynamically similar to nature. They are "simply considered to be small landforms."

Those who have followed the journal literature in this area will recognize many of the experiments. Parker and Mosley's tests of the Glock model for drainage network evolution are here, along with Parker and Harvey's experiments that led to the concepts of episodic behavior and complex response. Here also are the flume experiments on channel planform as a function of slope, water discharge, and sediment type that underlie Schumm's oft-reproduced classification diagram of alluvial channels. Gardner and Shepard's studies of entrenched bedrock meanders (in a cohesive clay and sand substrate) and the more recent studies of flume-channel response to local deformation of the bed (effected by jacking up the middle section of the flume) and alluvial fan morphology and dynamics round out the treatment. This presentation of previously published material is not necessarily redundant. The whole body of work now can be seen in toto and in much greater detail. In addition, each topic is placed in context by concise summaries of other work, especially field and theoretical studies. The resulting collection is not a treatise on experimental fluvial geomorphology, as its title implies, but more a peripatetic autobiography of sorts for the senior author. But it is a testimony to his breadth that the title fits at all.

This is a useful book, one that would please Judge Kroninger. It demonstrates an underused methodology for understanding teleconnections within the fluvial system, and it presents the basic experiments that have led to several important theories of landform behavior. But you must believe that the results from these "small landforms" can be applied to the world at large.

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