protest against the racism, imposed by the U.S. armed forces, that rejected Negro donors and denied Drew himself the right to give blood.

Instead, he departed for the prosaic reason that his leave of absence from Howard was up. Back in Washington, he advanced steadily: professor of surgery at Howard, chief surgeon at Freedmen's Hospital, and examiner for the American Board of Surgery. He found in teaching—rather than science, administration, or clinical medicine—the true theme of his career. Stern, sometimes self-righteous, he changed black surgical training forever by insisting on the highest of standards and taking no excuses. Yet discrimination still dogged him; Drew was never able to join the American Medical Association, because the local chapter was segregated.

His death following an automobile accident in North Carolina begot the most durable of the legends that surround him. Wynes carefully demolishes the story that Drew was denied treatment in a segregated hospital. The reality of the racism that Drew faced throughout his life was far more complicated, for his white countrymen acknowledged his genius even as they denied him justice. Wynes's conscientious little study, despite some labored writing, recovers that complex reality in the image of a scientist and teacher who died before his time.

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Problems of Connectionism

Connections and Symbols. STEVEN PINKER and JACQUES MEHLER, Eds. MIT Press, Cambridge, MA, 1988. viii, 255 pp., illus. Paper, $17.50. Reprinted from *Cognition*, vol. 28 (1988).

Associationism has returned to cognitive psychology in the sophisticated new form known as neural networks, or connectionism. The fact that a number of present practitioners do not want associationism back has resulted in the present volume of superb critical essays.

What are connectionist models? In such models, a set of input nodes is connected to a set of output nodes. Various weights of excitability or inhibition from each input node to each output node are given. When a set of input nodes is fired, a number of the output nodes have some probability of firing as a result of the connections. Corrective or feedback mechanisms can adjust the weights of various connections, so that the system can in effect learn from experience. In principle, anything can be connected to anything. The ingenuity of the individual investigator determines where and how strikingly the model can be applied.

From some early and interesting applications such as graded perception of category membership and the prediction of typewriter error patterns, investigators have recently gone on to elaborate attempts to simulate performance and learning patterns in language, the favored domain of non-associationist, higher-order structural cognition.

In particular, a recent model by David Rumelhart and Jay McClelland simulated the patterns over time of children's production of overregularized past tenses like *breaked* and *eated*, using only various collections of phonological stuff to represent the words; there are no rules or higher-order symbols like "verb" in the model. Perhaps, Rumelhart and McClelland suggest, most higher-order symbols can eventually be dispensed with in this way, along with linguistic rules. Other investigators have attempted to model sentence grammar (though by using form classes like "adjective" and noun" as the node-level labels).

These responses to the new associationism consist of three major essays. The first essay, by Fodor and Pylyshyn, points to the representational incapacity of connectionist models to capture some of the basic properties of human language. For example, human languages are *compositional*, in that the same item can be used in different places and still be the same item—the word *big* has the same relation to *dog* in *the big dog* and in *the dog is big*. This, surprisingly, connectionists cannot capture. Another missing property is the capacity to treat words or groups of words as individual units at one level but as part of a single higher unit at another. As one example, the unit "sentence" can itself contain other sentences as units, as in embedded sentences or relative clauses. Indeed, there are rules that affect a particular phrase unit, like a noun phrase, within one of these embedded sentences. Connectionist representations cannot say this sort of thing.

Fodor and Pylyshyn argue that to the degree these properties (and other properties of sentences that they discuss) are characteristic of human thoughts behind the sentences, connectionist models must be inadequate as general models of thought as well. Thus, connectionist inadequacies go beyond linguistic structure to thought structure.

In the second essay, Pinker and Prince give a thoroughgoing and sharp-etched critique of McClelland and Rumelhart's model of children's past-tensing. They too note how the notion that generalizations apply to units at different levels of analysis cannot be captured: some linguistic generalizations apply to individual sounds, some to their combinations, some to the combinations of words, and so on. They also question the actual success of the model. It does not, for example, stabilize on correct usage; it continues to produce many past-tense errors, whereas adults do not. It makes errors no one makes. Perhaps most devastatingly, Pinker and Prince point out that the model makes, and apparently must make, certain assumptions about the changing input to children that are factually incorrect. Early on, the model is given a sample of present and past forms of eight irregular verbs and two regulars. During this time, the model, like children, makes no overregularizations such as *breaked*. Then the input is changed to hundreds of verbs, in the reversed ratio 80 percent regular to 20 percent irregular, and overregularizations are now produced. But Pinker and Prince's inspection of children's transcripts shows no such radical change in regular-irregular ratios in either the environment for children or children's own vocabularies as they pass from accurate to overregularization uses. Thus children's performance changes without the corresponding dramatic changes in environmental input needed by the model.

Lachter and Bever's essay is devoted largely to showing that when the microstructural connectionist models do work (to some degree) on language problems, it is only because they are carefully designed to take into account implicitly the macrostructure the effects of which are to be aimed at. Their criticism can be analogized as follows. Suppose someone found an office staff with each person apparently doing just his or her own isolated function. One might find it amazing how this set of isolated microfunctions could have effects as though it followed a larger macroorganization. But of course this is neither a coincidence nor a miracle, for everyone has been assigned these apparently isolated microfunctions in a way precisely determined by the macrostructural aims. Lachter and Bever proceed to show this is what happens in connectionist models of linguistic behavior.

The authors in this volume are all impressed by some facet of connectionist successes and suggest some role for connectionism as an implementor of lower-order processes, directed by higher-order ones. At the same time, they express puzzlement as to why connectionist theories have gained at the expense of symbol-based, rule-based ones. They note that connectionist models naturally produce some favorable effects such as gradedness of response but argue that symbol-based ones can also do so. They

fail to note, however, that symbol-based models can often do so only in the way elephants can do seal tricks—somewhat unnaturally. Also, the connectionist "abolition" of higher-order symbols is an attractive scientific goal. For it would show there is a "deeper" reality to surface appearances, just as apparently unitary matter turns out to be made of microlevel parts that look as though they act as units.

If somewhat weak on analyzing the attraction of connectionist models, though, these papers are brilliantly apt in analyzing their present and perhaps permanent difficulties. Indeed, some of the critical arguments seem quite simply and straightforwardly correct, especially the general ones in the initial essay by Fodor and Pylyshyn (some of which are repeated in various forms in the later essays). It seems unlikely that connectionism in its present forms can cope with these difficulties; a connectionism that could cope would be one in which the basic equipment necessarily lost the stripped-down representational nature that constitutes much of the appeal of the present forms.

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A Burst of Phages

The Bacteriophages. RICHARD CALENDAR, Ed. In two volumes. Vol. 1, xviii, 596 pp., illus. $105. Vol. 2, xviii, 760 pp., illus. $125. Plenum, New York, 1988. The Viruses.

In these two volumes Calendar has assembled an excellent collection of papers summarizing the life history or the development of the major groups of bacteriophages. All the favorites are here, though λ is covered more as a collection of components than as an intact organism. Also reviewed are several lesser-known phages including the much-maligned T1 (Drexler remonstrates against those who live in dread of this phage), *Bacillus subtilis* phages, cyanophages, and the various viruses that parasitize the equally various archaebacteria.

Many of the phages whose life-style is described in these volumes have not been the subject of a comprehensive review for several years and, if for no other reason, their presence here is welcome. Others, T4 and Mu among them, are the subject of recent monographs, but Mosig and Eiserling (T4) and Harshey (Mu) have largely succeeded in avoiding duplication of detailed material.

The dust jackets of the volumes refer to two types of papers: discussions of issues exemplified by many kinds of phages and comprehensive reviews of individual phage families. Both volumes contain both types, and their order of presentation is randomly permuted. However, the chapters are all independent and are unlikely to be read in sequence. Nevertheless, I would have liked to have seen the detailed list of the contents of both volumes in each. I would also like to have seen a chapter including both a retrospective analysis of bacteriophage biology and an optimistic prognosis. We are still faced with many fundamental questions, the answers to which may best be obtained by studying these "simple" organisms. An enthusiastic, but considered, summary might have been infectious and helped stem the decline in popularity of phage research.

Including general reviews and specialized papers in one publication almost necessarily leads to repetition. This is especially noticeable when the chapters "Changes in RNA polymerase" and "Strategies of DNA replication" are compared with chapters on individual phages. Readers familiar with these topics will no doubt prefer the pertinent sections in the more specialized chapters, though even they may be rewarded by perusing these overviews. The introduction to "Strategies . . ." by Keppel *et al.* is particularly thoughtful.

Few of the papers on double-stranded DNA phages cover morphogenesis in detail, but this complex topic is thoroughly discussed in the contributions of Casjens and Hendrix (dsDNA phage assembly) and Black (DNA packaging). Both reviews are written with exceptional clarity, and even a casual reading of them should provide the nonspecialist with a good grasp of the subject and of the problems yet to be solved.

The reader will find little information on recombinant DNA technology in these pages. The use of phages as cloning or sequencing vectors receives only a couple of passing comments, and there is no description of phages that yield blue (or sometimes white) plaques. These topics are well covered elsewhere, and their absence from *The Bacteriophages* is probably intentional. What one will generally find, in the chapters on individual phage families, are comprehensive and often stimulating discussions of a diverse group of organisms. As might be expected, the contributions vary in quality, but any disappointments I may have had while reading some were more than compensated by the pleasures of reading others. Of several superb essays on individual phage families, that by Yarmolinsky and Sternberg stands out, partly because it occupies a quarter of a 13-chapter volume. Readers of this essay, while learning more than they thought possible about P1, can also feast on its fine English, its coarse French, and its humorous anecdotes.

These two volumes summarize our current knowledge of all the major groups of phages. The diversity of pathways used by one or another phage in subsuming the biosynthetic machinery of the host in order to promote its own development is truly remarkable. These strategies are well documented, with comprehensive reference lists extending into 1987 and even 1988. Anyone who wants to find a precedent for a particular mechanism of, for example, gene regulation is more than likely to find it in *The Bacteriophages*. These volumes contain a mine of information and ideas that are pertinent to all facets of biology. Both students and researchers should find them a valuable resource.

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Cementation Patterns

Diagenesis of Sedimentary Sequences. J. D. MARSHALL, Ed. Published for the Geological Society by Blackwell Scientific, Palo Alto, CA, 1988. vii, 360 pp., illus., + plates. $135. Geological Society Special Publication no. 36. Based on a meeting, Liverpool, U.K., Sept. 1986.

The process known as diagenesis is the sum of physical inorganic chemical or biochemical changes, excluding metamorphism, in a sedimentary deposit after its initial accumulation. It involves compaction, addition of material, removal of material, and transformation of material by change of mineral phase or replacement of one mineral phase by another. The most important aspect of the process is the transformation of loose sedimentary particles into solid bedrock by cementation.

As well as being of academic interest diagenesis has applications in the industrial sphere. The location of oil, gas, and water depends on the presence of pores that have escaped cementation or have been created through dissolution of newly formed cement or of particles of the original sediment. Pores such as vugs, channels, and caves resulting from percolating subsurface dissolution of the rock generate space of possible use for the disposal of industrial waste.

The aim of the meeting at which the papers collected in this volume were presented was to bring together workers on different kinds of sedimentary rocks. The