the number of ticks. Roscoe R. Spencer and Ralph R. Parker eventually developed a vaccine produced from ground-up ticks, according to Harden "the first human vaccine prepared from the bodies of arthropod vectors." Improved vaccines dramatically reduced the danger of spotted fever, and with the introduction of broad-spectrum antibiotics a cure had been found. Antibiotics and insecticides used to reduce the tick population, although not eliminating the disease, brought it safely under control.

Complacency among the scientific community and the public alike caused a reduction in research in spotted fever after World War II. But as suburbanization stimulated development in tick-infected areas, the number of cases began to rise. By the 1970s researchers were again at work looking for more sophisticated ways to combat the disease. "The history of Rocky Mountain spotted fever," Harden concludes, "stands not only as a tribute to organized inquiry in the medical sciences but also as a reminder that, because humans and microorganisms share the earth's biosystem, vigilance against infectious diseases must continually be maintained." Her excellent study greatly increases our knowledge and understanding of these important issues.

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The Auditory Scene

Auditory Scene Analysis. The Perceptual Organization of Sound. ALBERT S. BREGMAN. MIT Press, Cambridge, MA, 1990. xvi, 773 pp., illus. $55. A Bradford Book.

How do we recognize and understand spoken words when we are talking to someone in a noisy room? A spectrogram of a word uttered in a quiet place is distinctive. Mixing a spoken word from one speaker with the babble from many others buries the frequency characteristics of the word so as to disguise it completely in the spectrogram, yet a speaker may still be easily understood. The phenomenon is not unique to speech. The voice of a trumpet is readily followed in the rich sound of the orchestra as a whole, and it is easy to shift attention from the sound of trumpets to the sound of violins. The ear is bombarded with a complex spectral tangle, yet we are able to follow the spectral signature unique to a given instrument.

To this formidable problem—the problem of analyzing the highly complex acoustic scene surrounding us into its meaningful perceptual constituents—Bregman has brought fresh wisdom. His book is a distinguished realization of an empirical and theoretical development in the world of psychoacoustics that began some 20 years ago. Earlier, psychoacousticians were addressing their efforts primarily to the classical psychophysics of simple auditory stimuli. The need to understand the acoustics and the principles underlying speech perception, however, stimulated a trend to study more complex acoustic signals. Recently, that has included the continuing study not only of speech perception but also of the more complex signals associated with, for example, profile analysis (here, *profile* refers to the pattern of intensity of partials in the spectrum) and the pitch, timbral, and rhythmic components and structures characteristic of Western music (see, for example, D. M. Green, *Profile Analysis*, Oxford University Press, 1988; S. Handel, *Listening*, MIT Press, 1989; and C. L. Krumhansl, *Cognitive Foundations of Musical Pitch*, Oxford University Press, 1990).

What is auditory scene analysis? In Bregman's words, it is "to take the sensory input and to derive a useful representation of reality from it." One of the primary functions of this analysis is "to decide which parts of the sensory stimulation are telling us about the same environmental object or event." The hearer accomplishes scene analysis, he argues, through an interaction between the organizational principles identified by Gestalt psychology and the phenomena associated with auditory stream segregation and integration.

With auditory stream segregation, things that sound alike (for example, that have the same overall pitch or timbre) as they move in time tend to be organized into distinct and separate acoustic objects or events. This organization depends on other things, of course, such as the rate at which auditory events occur. For example, if the notes of two familiar melodies are alternated in sequence in the same pitch region, we hear a mishmash and are unable to distinguish the melodies. But if we gradually move the two melodies apart so that one becomes progressively higher in overall pitch while the other becomes lower, they begin to emerge as two distinguishable streams. This is so even though the acoustic stimulus still consists of a sequence of pitches alternating note by note from one melody to the other. Grouping principles have coalesced the ongoing auditory information into high and low streams—into distinct auditory events that go together in time.

If stream segregation describes the conditions in which ongoing auditory events will stream together in time, then how does the auditory system assure that events occurring simultaneously in that stream will be perceived as distinct events? And what facets of our perceptual experience depend on this grouping? One principle is that of the "old-plus-new" heuristic. Our auditory systems use this rule as follows: if in a stream of simultaneous auditory events one event can be reasonably grouped with its predecessor, then do so, remove it from the mixture, and go on to similarly analyze the remaining events in the simultaneity. This thinking obviously leads to a stress on spectral organization and analysis—it asks not only when spectral components of complex sounds will fuse, but also when they will segregate into perceptually independent events. Another principle is that of "exclusive allocation." Here the claim, backed by much evidence, is that the auditory system tends to place acoustic events into one stream or another, but not at the same time into two or more.

Are the processes of auditory scene analysis all innate and governed solely by the unlearned primitives of Gestalt psychology? Not at all. There is much evidence, especially from studies of speech perception, that the auditory system supplies information based on experience to interpret and "fill in" the ongoing acoustic stream. Auditory interpretations based on familiarity lead to the idea of "schema-based organization." In other words, auditory scene analysis depends on two overarching principles: primitive analysis, which is unlearned and effortless, and schema-based organization, which is learned and summons active attention to auditory information.

In two shorter chapters, Bregman applies his ideas specifically to the worlds of music and speech. His approach offers a wonderful way of thinking about these domains. In the chapter on music, for example, he shows how composers have implicitly incorporated principles of auditory scene analysis in their music. In his book in general, and in this chapter in particular, Bregman sketches the principles necessary for a formalization of many intuitive principles that have been used skillfully by auditory artists for years. In that sense, the book joins others written recently, such as Lerdahl and Jackendoff's *A Generative Theory of Tonal Music* (Harvard University Press, 1983) and Krumhansl's *Cognitive Foundations of Musical Pitch*, which have sought to provide formal explanations for the perception of music.

Outside of the world of research on audition and hearing, who will find this book of interest? Bregman presents his ideas as a challenge for those interested, for example, in artificial intelligence and the general formalizations it can provide. Similarly, the theory and data under discussion will provide major guideposts to the functional neurology of complex acoustic perception.

It is worth noting that Bregman's ideas stretch beyond the sphere of human perception to the world of all animals who perceive acoustic information. Although a few behavioral scientists have recently begun to address animals' perception of complex auditory information, no one has yet approached the problem from Bregman's point of view.

Bregman has written a major book, a unique and important contribution to the rapidly expanding field of complex auditory perception. This is a big, rich, and fulfilling piece of work that deserves the wide audience it is sure to attract.

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Molecular Gerontology

Molecular Biology of Aging. CALEB E. FINCH and THOMAS E. JOHNSON, Eds. Wiley-Liss, New York, 1990. xviii, 430 pp., illus. $110. UCLA Symposia on Molecular and Cellular Biology, vol. 123. From a colloquium, Santa Fe, NM, March 1989.

The promise that complex biological processes may be understood—at least in broad outline—at a molecular or biochemical level has begun to be fulfilled for some areas of biology. Thus, the molecular biology of development and cancer are tangible and viable fields, although still in their infancy. In other areas, the promise is as yet mostly unrealized, but the hope that molecular biology will soon help penetrate the mysteries of brain function or aging, for example, is stronger than ever.

Readers expecting to find in the present volume molecular paradigms for organismal or cellular aging will be largely disappointed, however. The book is more a testimony to hope in the power of molecular biology than a documentation of its achievements in aging research.

The book covers a diverse range of topics in genetics, biochemistry, and cell biology as they relate to aging in intact organisms or cultured cells. The diversity of topics reflects the pleiotropic effects of aging—even when studied in simple cell culture systems. There are chapters on the genetics of life-span in yeast, nematodes, insects, and mice; the incidence and repair of radiation-induced and oxidative damage to DNA, proteins, and cell membranes; the control of DNA replication and cell proliferation; selective and programmed cell death; and the control of general and specific gene expression. Even with such a broad range of topics, the book falls short of being really comprehensive. For the knowledgeable reader, however, most of the chapters will serve as accessible and concise introductions or updates.

In most of the book's 27 chapters, the authors clearly relate their data to organismal or cellular aging, if not directly through experimental design, then indirectly through often (but not always) lucid discussions. There are a few chapters that clearly show the successful and promising use of molecular biology to study aging. The best of these is a chapter that describes the cloning of a gene that extends the lifespan of the nematode *Caenorhabditis elegans*. A few other chapters describe preliminary data on how cloning and a genetically malleable organism can be used to isolate similar candidate genes.

The majority of the chapters describe studies in which a molecular biological approach is apparent, but only in a very preliminary form. Some of these chapters are certainly stimulating, but a molecular framework for understanding the age-related phenomenon under study must often be teased out by the reader. For example, there are studies describing age-associated alterations in the mRNA levels for several genes, some of which—such as those involved in the stress response or in protection from oxidative damage—are good candidates for playing important roles in aging. However, few studies have gone beyond simple measurements of mRNA abundance. On the other hand, there are chapters describing novel ways to measure the accumulation of mutations in intact organisms or the use of transgenic animals to study transcriptional control, but none report results of these techniques applied to aging organisms or cells. The value in many of these chapters lies not so much in their content as in the implications of the approach and the data for directions for future research. And recent studies from these authors and other laboratories suggest that the data in some of these chapters are indeed interesting springboards for more molecular analyses.

Finally, there are several chapters that describe studies that are either derivative in nature, outdated, or of marginal relevance to organismal or cellular aging. A more vigorous use of editorial veto power would have yielded a book of more uniform quality and interest.

If this book has a dearth of chapters on novel genes, their introduction into cells or organisms, the identification of age-specific regulatory DNA sequences or nucleic acid binding proteins, and other hallmarks of the arrival of molecular biology to a field, it reflects the situation of molecular aging research. Important steps have clearly been taken, and if the molecular biology of aging