taxa possessed an exuberance of cephalic appendages, many of which were apparently replaced in a similar fashion.

The consideration of the social significance of antlers, explanations for which are much less clear-cut and much more diverse than most biologists probably realize, permits Goss to lay the foundations of a theme that permeates the rest of the volume: biological phenomena (one is tempted to emphasize especially those associated with development, sensu lato) cannot be understood unless appropriate attention is paid to the organisms living in their natural environments.

Chapters 6 through 8 review the postnatal appearance and histogenesis of normal antlers and compare the information with that for other regenerating systems. Chapters 9 and 10 address the subject of abnormal antlers and discuss the matter of symmetry versus asymmetry. The latter question is part of an issue of great current interest to developmental biologists, pattern formation, and thus deserves wide attention. In addition these data lead the reader from consideration of the genetic underpinnings of antlers to consideration of the effects of external environmental cues, especially light, and the internal environment on their growth. Because most biologists probably assume that sex steroids are predominantly important in this context, two issues should attract the attention of endocrinologists. First, whereas circ-annual patterns of circulating titers of testosterone correlate clearly with the cycle of antler production, spermatogenesis and sexual behavior, each equally influenced by the steroid, vary subtly in their relation to antler growth and shedding in different species. Second, in spite of the copious documentation of the effects of photoperiodicity on the cyclic production of antlers, experiments involving pinealectomy have proved quite inconclusive—the cycles remain, but are delayed. The author emphasizes the promise the study of antlers offers to further our understanding of biological rhythms.

Chapters 13 and 14 provide ample evidence of the value of studying "exotic" phenomena with regard to furthering our understanding of clinical problems. Castrated deer produce antleromas, which, because they grow continuously, not only are extraordinary models for studying tumor growth (although, in contrast to horns, where squamous cell carcinomas occur, antleromas never metastasize) but also manifest cellular pathologies comparable to keloids or hypertrophic scars. That antlered does and antlerless bucks are known to be fertile is, in the author's words, "a reminder of how fragile the distinction between the sexes can be" (p. 288); reference to and discussion of human clinical malformations and dysfunction with reference to the anatomy and physiology of reproduction accompany these data.

The final chapter, on the medicinal uses of antlers, is historically and ethnologically fascinating but simultaneously evokes hope and sadness concerning the relation between humans and nature. Goss refrains from speculation on how or when in prehistoric times some Oriental (?) shaman proposed a variety of therapeutic purposes for antlers and other cephalic appendages. What are currently known as Grade A cervid antlers must be obtained at a stage in their development when they contain a maximum of testosterone, a fact that gives some credibility to the putative aphrodisiac qualities of cephalic appendages. The world's rhinoceroses are being slaughtered at a horrifying rate on the patently impossible assumption that their horns (concentrations of hair) have such properties. Europeans carelessly introduced deer into New Zealand to the detriment of the endemic flora and fauna; when their populations began to damage pasturelands they were slaughtered en masse from the air. A new business of farming antlers, a renewable resource, has developed in New Zealand over the past 20 years to meet the demands of the Oriental marketplaces. However humane the methods used in this industry, one wishes that *Homo sapiens* in the late 20th century would not earn money by mutilating one species, even if others might survive, albeit marginally, as a result.

Goss's precise yet fluid style of writing highlights our areas of knowledge and ignorance. A reviewer cannot begin to convey the wealth of fascinating data in this handsomely produced volume with excellent bibliographies for each chapter and a comprehensive index. Its contents reveal how unicorns *could* have been recognized (at least those with cloven hooves) and will have broad appeal to a large audience. The layman who studies deer along the sites of a hunting rifle has provided many useful data in the past and will find here more useful things to look out for; professional biologists from every discipline will find this book a source of enormous delight and interest.

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Microbial Growth

Growth of the Bacterial Cell. JOHN L. INGRAHAM, OLE MAALØE, and FREDERICK C. NEIDHARDT. Sinauer, Sunderland, Mass., 1983. xii, 436 pp., illus. $25.

This textbook on microbial physiology was written for advanced undergraduate and graduate students who have a background in biochemistry and genetics. It would be an appropriate textbook for a specialized course on microbial biosynthesis that followed a broadly based course on microbial physiology. The book is concerned with the biosynthesis of cell material and covers the energetics and regulation of cell synthesis in great detail. Only 20 pages are devoted to catabolism of organic compounds, and these primarily show how catabolic pathways provide the precursors for biosynthesis. The authors have restricted themselves to results obtained with *Escherichia coli* or its cousin *Salmonella typhimurium*. This approach excludes a number of interesting topics, such as the cell cycles of *Caulobacter* and myxobacteria and sporulation in *Bacillus*. However, it does keep the development of topics on track by avoiding bacteria that have unique characteristics. Furthermore, as the authors correctly point out, many of the critical discoveries in microbial physiology were made with the use of enteric bacteria. The book emphasizes an experimental approach to the topic. Several chapters include some discussion of applicable experimental techniques, and this material is very appropriate in an advanced textbook.

After an opening chapter on the composition and structure of *Escherichia coli* to orient the reader, the authors begin their discussion of biosynthesis by considering the assembly of supramolecular structures in chapter 2. In the next chapter, macromolecular polymerization and the biosynthesis of building blocks are covered in a novel and illuminating fashion. Not only are mechanisms and pathways discussed, but in a series of tables the energetic costs of macromolecules and building block biosynthesis are calculated. This approach provides much insight into what is involved in the synthesis of an *E. coli* cell. For example, the tables illustrate that 96 percent of the energy costs for polymerizing macromolecules is expended in making protein and that *E. coli* expends seven times more energy in a minimal growth medium than in a rich medium to provide the building blocks for macromolecular synthesis. This chapter is the strongest in the book,

and it is a valuable collection of information for the microbial physiologist.

The next chapter presents material on the isolation and recognition of bacterial mutants and discusses the types of lesions in DNA that occur in mutants. Finally, it presents the mechanisms of genetic exchange in *E. coli*. This chapter does not cover these topics to exhaustion but does provide sufficient background for the student to appreciate chapter 7, which discusses the lactose, arabinose, and tryptophan operons, as well as the molecular genetics of control of gene expression for ribosomal proteins.

Two chapters are concerned with growth rate. The first considers primarily the kinetics of bacterial growth. In general, it is a very good discussion of the important concepts in this subject. However, the authors may have added confusion to a point that is already befuddling to students. Two growth rate parameters, μ and k, are used by microbial physiologists. They differ in the base of the logarithm used to define them mathematically. The authors define these parameters using a convention opposite to that used by most other microbiology textbooks, although they consistently and correctly use the appropriate parameter given their definitions.

The last chaper, "Regulation at the whole cell level," discusses results from experiments employing shifts between growth conditions and the role of guanosine tetraphosphate in regulation. Much of this material concerns the research of Maaløe and Neidhardt. Perhaps as a result the treatment is of the sort I would expect to see in a monograph rather than in a textbook. There are four informative and useful appendixes, which include a genetic catalog of *E. coli* and a short discussion of methods used for genetic mapping.

Several features make the book useful to students. Each chapter has a summary of important concepts. Each chapter also has a short list of references, including primary sources as well as reviews. The references include some of the most significant papers on the physiology of *E. coli* from the previous two decades. Finally, some chapters have problems for students to solve.

This book is no replacement for a textbook on microbial biochemistry or genetics and does not pretend to be. However, it does an exceptional job in covering a specific topic, the physiology of growth. In addition to its use as a textbook, it should be read by all microbial physiologists, because it provides marvelous insight into the way a microorganism must coordinate its metabolism. It is also a valuable reference volume that documents the energetic costs that *E. coli* must pay to procreate.

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Neural Circuitry

Chemical Neuroanatomy. P. C. EMSON, Ed. Raven, New York, 1983. xiv, 560 pp., illus. $75.

It has been known for many years that the integrative functions of the nervous system are subserved by circuits that rely on the transmission of electrical impulses along axons and on the release of neurotransmitters at synapses. The work of pioneers like Ramón y Cajal at the turn of the century outlined the basic architecture of this circuitry and demonstrated that it is made up of literally thousands of distinct cell types that are connected in a very precise way. The identification of neurotransmitters in specific cell types progressed much more slowly, so that by 1960 it was only known with certainty that acetylcholine and norepinephrine were utilized by neurons in certain parts of the peripheral nervous system.

The situation changed dramatically in 1962 with the introduction by Carlsson, Falck, and Hillarp of a histofluorescence method for the cellular localization of norepinephrine, dopamine, and serotonin in the brain. This method indicated which cells and fibers in the brain may contain these biogenic amines, and, particularly in the hands of Foxe and Dahlstrom, it also revealed the existence of three major previously unknown neural systems. These systems revolutionized thinking in neuroanatomy because they were unlike any others known since the time of Cajal: small groups of neurons in the brainstem appeared to innervate most parts of the central nervous system in what seemed at least initially to be a rather nonspecific way.

The power of the method was that it provided a bridge between anatomy, biochemistry, and pharmacology, and its most visible success was the identification of dopamine cell death in Parkinson's disease, which resulted in treatment of the disease with L-dopa. About ten years later, in the early 1970's, the scope of this approach was greatly expanded when Hartman and Barry applied immunohistochemical methods to the cellular localization of a wide range of antigens associated with neurotransmitters. In the last few years literally dozens of possible neurotransmitters have been identified chemically. In addition to acetylcholine and the biogenic amines, certain amino acids, and a whole host of peptides, are now thought to act as neurotransmitters (or at least as neuromodulators) in the nervous system. Presumably, each of these molecules interacts with receptors at the synapse, and a variety of histological methods are also available to localize their distribution in tissue sections.

The book edited by Emson is a timely review of what is currently known about the cellular distribution of putative neurotransmitters and their receptors in the mammalian nervous system. The vast literature on the topic is rather thoroughly covered in 13 review chapters. The material in the book is arranged along topographical lines so that each chapter deals with a major subdivision of the nervous system, such as the peripheral system, the spinal cord, the thalamus, and the retina. And since each chapter systematically reviews what is known about the cellular localization of putative neurotransmitters, workers in all branches of neuroscience will find the book an invaluable and convenient guide to a vast literature.

The book is particularly interesting because it appears at a time when chemical neuroanatomy is moving from one era to another, more mature era. The first, which is summarized here, involved the development of radically new techniques and at least conceptually was based largely on the descriptive neuroanatomical approach of the 19th century. Thus, a great deal of the work focused on determining which cell types and fiber systems contain a particular neuroactive substance. The second era, which has slowly gained momentum, involves the experimental dissection of biochemically specific pathways and the elucidation of their precise role in the functional systems that have been established with more traditional anatomical, electrophysiological, and behavioral approaches. The beauty and specificity of immunohistochemical staining have tended to seduce workers into focusing on small groups of neurons without considering their relationship to classical neuroanatomical circuitry. There are at least two reasons for this. First, a great many peptides have been localized preferentially in parts of the brain that are the