one of the very few accounts of the limnology of a river in the tropics, and a very complete and up-to-date bibliography. I hope that it will serve as an example to biologists in other tropical lands where streams are just as threatened by man's activities as are temperate ones. May they also be inspired to go out and find out about their own rivers and from what they need protection.

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Determination of Sex

Genetics of Sex Differentiation. URSULA MITTWOCH. Academic Press, New York, 1973. xiv, 254 pp., illus. $16.50.

While there are numerous theories on the mechanism of sex differentiation, particularly in mammals, no single hypothesis has gained general acceptance. Ursula Mittwoch, who has made important contributions in the past in her studies of nuclear sexing, here presents a distillation of her current ideas on the role of the sex chromosomes in development. She suggests that it may be the mitotic regulatory effects of the X and Y chromosomes that determine gonadal differentiation. She further argues that the differential growth of XX and XY cells is mediated by specific chromosomal regions as well as by intrauterine environmental factors. Mittwoch has obviously come to the conclusion that simple genic determination of the sexual phenotype is invalid.

Fortunately, Mittwoch has developed her arguments in a way that gives the book merit well beyond that of its underlying thesis. She has, for example, provided an incisive review of the classical concepts of sex determination and discussed the possible role of heterochromatin in sex differentiation. She points out that the sex chromosomes contain an inordinate amount of facultative, as opposed to constitutive (or structural), heterochromatin, with the best example of facultative heterochromatinization being the genetic inactivation of one of the two homologous X chromosomes in the mammalian female cell. The critical nature of the largely heterochromatic Y chromosome in sexual differentiation has long been recognized, but the mechanism of Y chromosome action is still not clear. Mittwoch argues against several hypotheses that have been proposed in recent years as alternatives to the classical idea of large numbers of male- and female-determining genes. For example, Hamerton has hypothesized that the Y bears a controlling center that activates a specific gene located on the X chromosome. This X-linked gene is said to produce an inducer which stimulates the medulla of the primitive gonad with subsequent differentiation of that gonad into a testis. As Mittwoch suggests, while the Y is indeed the primary sex determiner, there is no evidence for an inducer gene, let alone for its location on the X chromosome.

The sex differentiation hypotheses of Boczowski and Ohno are also discussed—Boczowski's idea requiring hypothetical genes on the X (a gonadal inhibitor gene) and Y (a repressor-producing gene which is specific for the X-linked inhibitor gene), and Ohno's requiring an X-linked regulator of testosterone production.

The reader interested in mechanisms of sex determination will find this a superb review not only of the traditional concepts of sexual differentiation but also of several of the more recent hypotheses. As Mittwoch admits, however, her own hypothesis is formulated as yet only in broad terms. While her hypothesis is thought-provoking, it, like the hypotheses she criticizes, is not totally acceptable. In support of the idea of chromosomal regulation of growth, Mittwoch cites the relationship of chromosomal volume to mitotic activity and the relationship of chromosomal size to the duration of the cell cycle. These observations are generally valid, but it is difficult, indeed, to see how the longer generation time of triploid and tetraploid nuclei may be compared with possible XX and XY replication differences. One can readily concur with Mittwoch's assessment of the limitation of viewing sex determination as the result of simple Mendelian gene control; but it is difficult to accept the notion that sex determination takes place on the basis of preferential growth of XY cells. Mittwoch's fundamental argument is that, in males, the testicular gonadal tissue grows faster than the primitive ovarian tissue because of the presence of a Y chromosome. She may be correct in this, but further proof is needed. With formation of the testis, androgens are secreted and masculinization of the reproductive tract is the result. The normal female reproductive tract is viewed as being produced simply in the absence of the masculinizing effect of fetal androgens.

Mittwoch's book is valuable, then, in two ways: First, it presents an excellent, updated review of fundamental aspects of sex determination, with the discussions of the formation and the function of X and Y heterochromatin being especially well done. Mittwoch ranges over a wide portion of the evolutionary tree in her discussion, which enhances the appeal of this book to biological scientists. Second, she reviews the major theories of sex determination and adds her own. While no one theory seems able as yet to explain sex determination in a totally satisfactory way, the ideas that are presented here are clearly among the best attempts.

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Activity of the Thymus

Thymic Hormones. T. D. LUCKEY, Ed. University Park Press, Baltimore, 1973. xviii, 376 pp., illus. $19.50.

Scientific interest in the thymus was awakened anew in 1960 when Good, Miller, and soon thereafter a host of other investigators demonstrated the critical role the thymus played in the development of the immune system. As so often happens when such a breakthrough occurs, the past is temporarily forgotten as the new concept coupled with new technology leads to a cascade of data and insights.

Thymic Hormones, edited by T. D. Luckey and authored by many of the old-timers in the thymus business, brings together a past and present perspective that should now be again incorporated into our thoughts regarding the role of the thymus. The subject of thymic hormones was, and in some respects remains, a very controversial one. Early work in this area was conceptually sound and fascinating, but the data resulting from much of the experimental work were thin and often failed to support the hypotheses convincingly. *Thymic Hormones* presents a thorough review of past as well as new work in this area. Much of the information is not readily available else-

where, and thus this review serves a useful purpose. The recent studies reported avail themselves of new technology and the knowledge gained from the 1960 cascade, thus creating an important link between the cellular and the humoral concepts of how the thymus influences the body.

The bibliography is extensive and valuable. This book should prove stimulating and useful, especially to those persons engaged in studying the role of the thymus from a cellular rather than a humoral point of view.

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The Biston Affair

The Evolution of Melanism. The Study of a Recurring Necessity. With Special Reference to Industrial Melanism in the Lepidoptera. BERNARD KETTLEWELL. Clarendon (Oxford University Press), New York, 1973. xxiv, 424 pp., illus. + plates. $33.

This is the masterwork of an extraordinary biologist. Twenty-five years ago, H. B. D. Kettlewell abandoned 15 years of medical practice to return permanently to the study of the Lepidoptera. As Nuffield Foundation Research Fellow at the University of Oxford, the amateur was converted to professional. Thus we have been treated to yet another spectacle of highly successful unorthodoxy in British science. Where else in the world do such things happen?

The short title is somewhat misleading. On first reading it I thought perhaps Kettlewell was going to deal broadly with blackness in nature. But, as the second subtitle suggests, the book centers on the author's principal research interest, the evolution of industrial melanism in moths. Perhaps this is for the best. The reader is led through 50 pages of an introductory nature, following a complex outline which deals with concepts, attributes, examples, functions, and classifications of melanism. The approach is pedantic and the style turgid, but coverage of individual topics is fortunately brief. I have the impression that the author felt obliged to introduce the subject in this broad way but his heart was not in it.

The tone of the book improves noticeably when we come to a 50-page review of "The phenomenon of industrial melanism." But all this is still only prologue and stage setting. Finally, the classical case of melanism in the peppered moth *Biston betularia* is adduced and dealt with in all its fascinating details. What has made the *Biston* affair an evolutionary classic is the wealth of data that have been brought to bear on it. Thus there is the history of the blackening of the environment of the English midlands, the knowledge of bird predators and their habits, and the genetic bases for the melanistic forms of the species. The climax is reached when Kettlewell recounts the actual details of his own ingenious experiments on the action of natural selection. All these things have made this the best-known and most dramatic case of adaptive evolution in action. This same need for documentation in breadth and depth deprives most of the other cases that Kettlewell reviews of the intense interest that centers around *Biston betularia*. They seem of secondary importance and beset with many of the same uncertainties that once surrounded *Biston*. Nevertheless, the author succeeds in demonstrating that manifold genetic melanisms exist quite apart from those that have evolved as a genetic response to industrial pollution. These provide valuable comparative insight into the *Biston* case. Especially useful in this regard are the data on two other moths, *Amanthes glareosa* in the Shetland Islands ("Northern melanism") and *Lasiocampa quercus* ("Recessive melanic polymorphisms") from northern Scotland.

The book concludes with a miscellany of melanisms including a brief excursion into polymorphism in butterflies. The chapter labeled "The synthesis" is only six pages, and one is left with the feeling that integration of these cases into modern evolutionary population genetics has yet to be satisfactorily done.

Although there are several useful appendices, very little previously unpublished material has been included, and the mode of presentation follows very closely that of Kettlewell's scientific papers. In some instances verbatim quotes are used, and many tables and figures are slightly altered versions of the original ones. What emerges, then, is a compilation rather than a synthesis. The usefulness of having all this material between two covers is slightly impaired by the fact that some reproductions of black-and-white photographs are not up to the quality of the original figures in the journals. There are, however, a number of fine colored plates.

Kettlewell's rugged individualism permeates the book. Here are his work, his impressions, his view of biology. His name dominates the bibliography and the index. I raise this point not in criticism but as a reminder, in these days of the "team effort" and the "crash program," of the importance of individual dedication in intellectual endeavor. Science has its social aspects; collaboration and communication are necessary, and indeed every new fact must be interpreted with regard to the foundation laid by others. Throughout Kettlewell's book he is at pains to make us aware of how much he has depended on the heritage of predecessors. For example, mating behavior in *Biston betularia* was first observed and studied by John Ray on 29 May 1673! Although 85 percent of the author's cited publications are without coauthors, he has nevertheless carefully paid tribute to those who have assisted and influenced him. They range from amateur collectors and observers to active field associates and many of the major figures in evolutionary genetics and ecology. Despite all this, however, it is the individual enthusiasm, the personal drive, and the fired curiosity that are of the essence of Kettlewell's work.

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Hard Tissue

Mechanical Properties of Bone. F. GAYNOR EVANS. Thomas, Springfield, Ill., 1973. xiv, 322 pp., illus. $25.75. American Lecture Series, No. 881.

Evans is well situated to write this book. In 1957 he wrote the seminal *Stress and Strain in Bones;* he works in Ann Arbor, one of the world centers of bone research; finally, most importantly, researchers on bone must continually quote his work because he has started so many fruitful investigations into this maddening tissue.

He does not try to update the earlier book. He deals with bone as a tissue rather than with whole bones, which were the subject of *Stress and Strain in Bones*. He adopts the tactic of considering, in turn, the effects of factors such as drying, age, sex, and strain rate on the measured mechanical properties.