The Acquisition of Sex

Molecular Genetics of Sex Determination. STEPHEN S. WACHTEL, Ed. Academic Press, San Diego, CA, 1993. xviii, 518 pp., illus. $89 or £68.

The most obvious—and, to many, the most fascinating—characteristic that distinguishes members of our own species from one another is gender. What is it that turns sexless human embryos into boys or girls in roughly equal proportions? And is "it" the same thing that determines sex in all other animals? Although questions of this type have been asked by many scientific thinkers since the days of Aristotle, it was only with the onset of 20th-century genetic analysis that they could begin to be answered. Surprisingly, unlike many other conserved biological features, sex is determined in a variety of ways in the animal world. In fact, in some unusual cases it is "nurture" (the environment) rather than "nature" (the genes) that does the job.

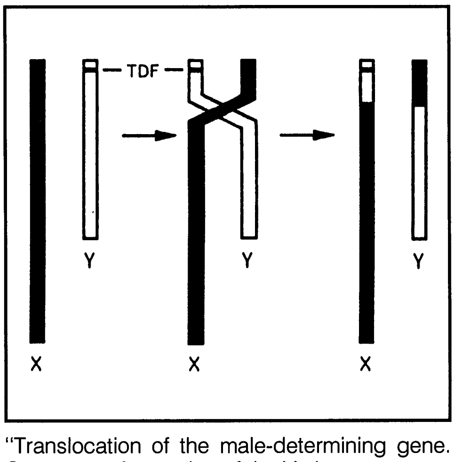
The first genetic system of sex determination to be understood at a basic level is the one that acts in *Drosophila melanogaster*. Male fruit flies have two sex chromosomes, X and Y, just like men. But the results of studies dating back to 1916 demonstrated that the Y chromosome itself does not play a role in sex determination. Rather, it is simply the number of X chromosomes (relative to a normal autosomal complement) that determines whether flies will develop as normal males or females. Could this be how gender is determined in humans as well?

It was not until 1959 that this question was answered: In humans (and, apparently, in all other mammals as well), the Y chromosome is required to direct embryos down the pathway of male development and away from the default pathway of female development. Further work pointed to the existence on the Y of a specific "testis-determining factor" (*TDF*) that induces the formation of testes in the undifferentiated fetal gonad; all other aspects of male sexual development follow from this initial event. Over the years, various molecular candidates for *TDF* have been put forward and shot down. These have included a cell-surface antigenic determinant (H-Y), a noncoding simple repeat sequence (Bkm), and a gene encoding a zinc finger protein (*ZFY*). Finally, as the climax of the final act in a long play, a gene that has demonstrable *TDF* activity, called *SRY*, was cloned and characterized by Goodfellow, Lovell-Badge, and their colleagues in 1990 and 1991.

Additional details from this scientific journey are recounted, often by the participants themselves, in *Molecular Genetics of Sex Determination*. The volume consists of 19 contributions by some of the most illustrious workers in the field, including early pioneers such as Anne McLaren, Mary Lyon, and Susumu Ohno. It should be pointed out that all the chapters but one focus on mammals, even though we have a much more advanced understanding of the details of sex determination in *Drosophila*, as described in the comprehensive overview of the topic by Cronmiller and Salz.

Many of the individual contributions to this book are excellent stand-alone reviews, and the book as a whole constitutes a valuable source of information on sex determination, the X and Y chromosomes, and sexual development—both normal and abnormal—in humans and mice. I found the rather personal chapter by Hampikian *et al.* on marsupials to be particularly useful in conjunction with the *Drosophila* chapter; together they provide a sense of the commonalities and differences that determine sexual dimorphism in each of these groups relative to each other and to the eutherian mouse-human group.

The book's only serious defect is its redundant coverage of the *SRY* gene, which is the focus of six different chapters, with many aspects of the work leading up to its discovery and characterization repeated over and over again. In addition, the book could have been made more accessible by better coordination of terminology in the final two contributions, which focus on the same protein—referred to as anti-Müllerian hormone (AMH) in one and as Müllerian-inhibiting substance (MIS) in the other.



"Translocation of the male-determining gene. Crossover of a portion of the Y chromosome to the X during meiosis. If the translocated portion contains the testis-determining gene, *TDF*, and if an egg is fertilized by the sperm carrying the X;Y translocation chromosome, the resulting embryo becomes an XX male. X–Y crossovers have been confirmed in most, but not all, 46,XX males." [From Wachtel and Tiersch's paper in *Molecular Genetics of Sex Determination*]

These problems notwithstanding, I suspect that anyone with even a peripheral interest in sex determination will enjoy this book and will be glad to have it handy for quick reference.

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Biological Patterns

Life History Invariants. Some Explorations of Symmetry in Evolutionary Biology. ERIC L. CHARNOV. Oxford University Press, New York, 1993. xvi, 167 pp., illus. $37.50 or £25; paper, $19.95 or £13.50.

Life-history theory seeks to explain patterns in demographic variables that are directly related to evolutionary fitness by simple quantitative expressions—for example, fecundity, mortality rate, development rate, age at maturity, allocation of resources between male and female sexual function, and senescence. Investigation of life histories has produced a substantial body of published work including, recently, several comprehensive syntheses. Not surprisingly, then, Charnov addresses many recurrent issues in this book, some of them developed in his earlier *The Theory of Sex Allocation* (Princeton University Press, 1982). What is new in *Life History Invariants* is the perspective of symmetry and invariance. Charnov's approach will be stimulating and provocative to those willing to consider his arguments carefully. This is not an easy book, but it is well worth the effort.

Life-history invariants are life-history variables that do not change through "transformations" as other aspects of the life history do with variation in body size or ecological relationships. Examples of such practically universal invariants are the 1:1 sex ratio of most populations of animals and the product of age at maturity (α) and adult mortality rate (M), both of which are elaborated in this book. Charnov points out that life-history invariants usually are dimensionless numbers and argues (p. 6) that "invariance at one level will almost always imply symmetry at a deeper level of causative factors." Thus, 1:1 sex ratios are seen as reflecting the "symmetry" that each individual has one mother and one father. Close inbreeding among siblings, which blurs the genetic distinction between "mother" and "father," and other gender-related ecological or social asymmetries