BOOK REVIEWS

Maleness and Femaleness

Sex Determination, Differentiation and Intersexuality in Placental Mammals. R. H. F. Hunter. Cambridge University Press, New York, 1995. xxii, 309 pp., illus., + plates. $79.95 or £50.

The sex of the mammalian embryo is determined at the moment of conception; if the egg is activated by a Y-bearing sperm, the fetus is destined to be male. But determination is not enough, and there is an enormous amount of differentiation that must occur to achieve what we recognize as the adult male phenotype. Prior to sex differentiation, the fetus is sexually neutral, with a primitive undifferentiated gonad and a double set of genital ducts. The first steps in sex differentiation occur in the male and involve changing the bipotential gonad into a testis and subsequent regression of one set of ducts. It is classically held that sex determination in mammals is a simple event in which perhaps only a single gene on the Y chromosome decides whether the generic gonad develops into a testis or an ovary. Female differentiation has been considered the default pathway, as it occurs only in the absence of a proper Y chromosome. After reading this book one will certainly agree with the author that "so splendid an organ as the functional testis (or ovary) must involve programming by many genes." Although he rejects the hypothesis that the road to female sex differentiation is merely a default pathway, there is little here that is contrary to it. The book deals mainly with these processes in the male, because so little is known about female sex differentiation.

Many genes have at one time been considered candidates for the sex determinant on the Y chromosome, including the HY antigen and the ZFY zinc finger protein, and these are discussed along with genes that play a role in the development of genital ducts and external genitalia. Two of them with important roles in male sex differentiation have been identified so far: one, the gene in the sex-determining region of the Y chromosome (SRY), has a pivotal role in the cascade leading to the differentiation of the testes; the other, the autosomal gene encoding the anti-Müllerian hormone (AMH) produced in testicular Sertoli cells, is responsible for the regression of Müllerian ducts, which are the ducts that in females develop into oviducts and uterus. Both are fully discussed with respect to what is known and what remains to be elucidated. We are reminded that despite the ever-increasing amount of detail available, the precise mechanisms underlying the conversion of a primitive gonad into testicular or ovarian tissue and the development of secondary sexual characteristics remain unknown.

Hunter's intent was to write an academic text for advanced undergraduates and graduate students interested in developmental biology and reproductive physiology, and the book is more concerned with physiology and genetics than with chemistry. It is a pleasure to read because of Hunter's clear style and elegant exposition, which, as he points out in another context, "are aspects of scholarship not always conspicuous in the latter part of the twentieth century." It is also a successful amalgamation of information from many mammalian species.

The normal mechanisms of sex determination and normal differentiation of the gonads and genital ducts are considered separately from the anomalous sexual development in domestic species, laboratory rodents, and humans. Each chapter was intended as an essay in its own right, which results in some repetition, but this is not a problem. The material of which I have prior knowledge is accurately summarized, and most of the important references are included. For me the best parts of the book are the first four chapters, dealing with the normal mechanisms, as they not only present the facts but also document well the history of these discoveries, providing insights into the scientific process; novel findings suggest hypotheses, which may later be rejected on the basis of new evidence. Clearly the search for genetic sex determinants has involved several false starts. I am not as enthusiastic about the presentation of abnormal sex differentiation, which seems to lack an organized approach and in many cases especially with respect to domestic animals, is phenomenological, mainly because the sexual phenotypes in those animals have not been well defined physiologically. Furthermore, the term "intersex" seems too general and too vague to be useful for the analysis of aberrations in the sex determination-differentiation pathway. On the other hand, the value of such mutants for elucidating normal mechanisms and as models for future studies is evident. Much of our knowledge about the fate of germ cells and the ontogeny of ovotestis in hermaphrodites comes from studies of XX-XY chimeras—mixed-cell lineages occurring spontaneously in humans and farm animals and those created in tetraparental rodents, which are discussed in the chapter on chimeras. The chapter that considers asymmetries in the reproductive system seems to belabor the matter; aside from the asymmetry in the rate of gonadal growth (testes ahead of ovary), which probably leads to earlier differentiation in the male, and the unexplained unilateral occurrence of ovotestes, the significance of asymmetries—such as unequal growth of left and right gonad and differences in distribution of germ cells and in testicular weights—is far from clear and may turn out to be trivial.

The many figures in the book are generally well done and helpful. The photographs are not as useful, mainly because of poor labeling. However, the frontispiece is an exceptionally fine photomicrograph showing the moment of sex determination in hamster oocytes.

I am pleased to have this concise and well-written summary of what is known and hypothesized about mammalian sex determination and differentiation on my shelf as a reference. The index is excellent, and there are many important references up to 1994.

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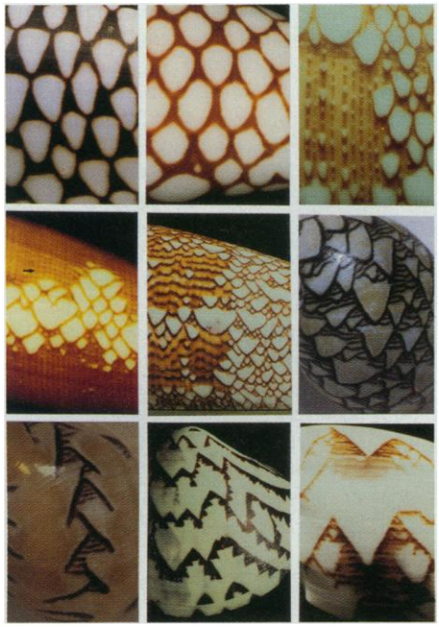
Patterns

The Algorithmic Beauty of Sea Shells. HANS MEINHARDT. Springer-Verlag, New York, 1995. xii, 204 pp., illus., + diskette. $49.95, DM78, öS608.40, or sFr75.

One of my earliest memories is of a collection of Kwakiutl hats owned by my paternal grandfather. These hats, common on the West Coast of Vancouver Island when he was a young man, were woven from cedar bark and bore elaborate designs inspired by the highly regular patterns on sea shells, particularly those of surf clams. The hats even looked like clam shells, designed to protect the wearer from the West Coast rains. I often wondered how the clams that inspired these patterns managed to create designs that were so similar from shell to shell and yet also different, both in the regularity of the pattern and in the detail. It seemed clear to me that a blueprint of some



A collection of complex shell patterns. "To show their inherent similarities, they are arranged such that each subsequent pattern contains elements of the preceding patterns as well as new features." [From *The Algorithmic Beauty of Sea Shells*]

kind was used by the animal but equally clear that individuals were exercising some artistic license.

The truth about these patterns still eludes us, and we know little about their cellular and molecular basis. But it is now fairly certain that periodic patterns in general can be explained by models that postulate short-range activating and long-range inhibiting forces. This idea, first outlined by Wigglesworth in 1940 to describe spatial patterns in insects, was cast in general chemical and mathematical terms by Allan Turing in 1952.

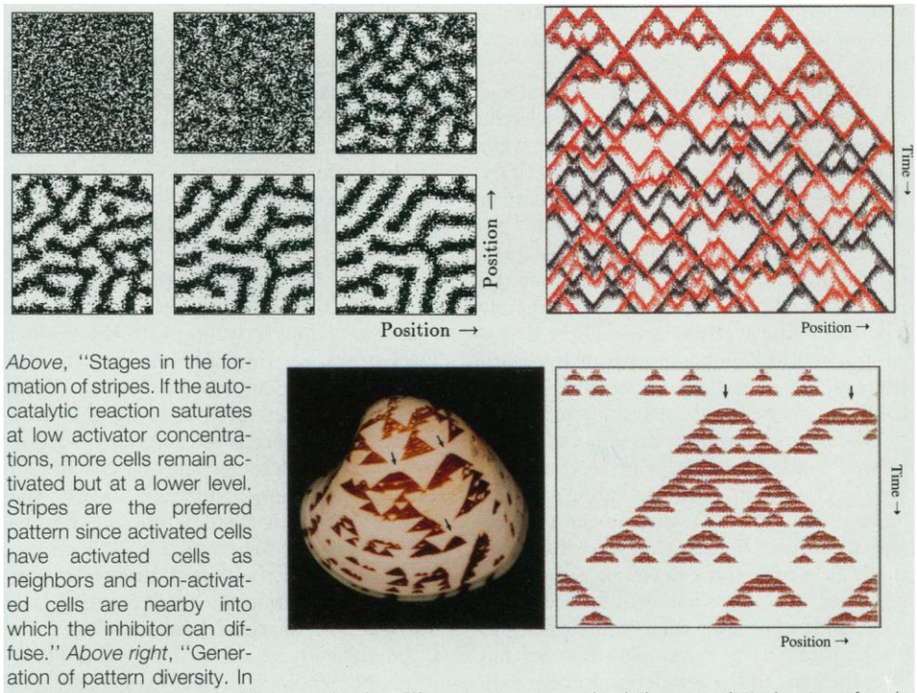
In this beautiful book Meinhardt sets out to convince us that models such as he and Alfred Gierer have developed to explain relatively simple patterns in animals and plants can indeed explain shell patterns. Their theory also invokes short-range activation and long-range inhibition. Meinhardt says in his introduction that he was inspired to try modeling shell patterns while dining on one of his subjects in an Italian restaurant. The task proved more difficult than he expected, given the complexity of many of the patterns in both space and time.

How successful has he been? How do we recognize success? Clearly, a model should account both for the theme and for the variations seen in the object of our attention, for both the blueprint and the artistic license. It should also have fewer parameters than there are variables in the pattern itself, otherwise it is just a representation of the data set. It should also capture the dynamics of the process, the intermediate states on the way to the final pattern. At the same time, there are demands we cannot reasonably make of the model in the absence of experimental results: it cannot be expected to distinguish one kind of chemical or physical basis for the patterning system from another.

It turns out that the explanatory power of the Meinhardt and Gierer formalism is very great indeed. Many of the patterns in this book have been plausibly simulated by computer using, for the most part, a pair of coupled non-linear differential equations. The generic patterns—parallel lines and tongues on *Clithon oualaniensis*, overlapping lines of parallel triangles in two colors on *Conus* species, bifurcating, diverging lines of pigment on the whelks, chains of connected triangles on *Lioconcha*, and mirror-symmetric patterns on the bivalve mollusks simulated by the Kwakiutl peoples with their hats—are faithfully reproduced. The variability from shell to shell is there too, as are some of the details of the transition from the initial to the final pattern. Occasionally the number of assumptions needed to explain the apparent superposition of two patterns pushes the reader's attention to the limit, but it is not clear that fewer assumptions would suffice. In any case, others should be stimulated by this work to try to design simpler models.

Przemyslaw Prusinkiewicz (the editor of the Virtual Laboratory series to which this book belongs) and Deborah R. Fowler have contributed a chapter to the book in which Meinhardt's simulations are run in three dimensions. These are very successful. Each is keyed to a figure in the text, and they have the look of the real object. The text is accompanied throughout by a DOS-based collection of programs and tours that are very easy to use and modify (instructions are included) on a 486 machine with a math co-processor. This is one of the strongest features of the book, since by varying parameters in the various algorithms one quickly develops a feel for the relative importance of the elements that make up each model.

How close, then, does this work bring us to an understanding of sea shell patterns? As I mentioned above, processes involving short-range activating and diffusing chemicals whose synthesis is coupled to the synthesis, decay, and diffusion of long-range inhibiting chemicals have formal properties that are generic, which is to say that many forms of short-range activation and long-range inhibition can be (and have been) imagined and studied. At about the same time Meinhardt realized that diffusing



Above, "Stages in the formation of stripes. If the autocatalytic reaction saturates at low activator concentrations, more cells remain activated but at a lower level. Stripes are the preferred pattern since activated cells have activated cells as neighbors and non-activated cells are nearby into which the inhibitor can diffuse." *Above right*, "Generation of pattern diversity. In order to show that minute differences lead to different patterns two simulations are plotted on top of each other (black and red)." Though "the same cells are activated initially . . . different random fluctuations exist. At early stages (top of the figure) both patterns are very similar; the black pattern is largely covered by the red. Small differences decide whether branch formation occurs. After a few generations of branching, the patterns are completely different." *Bottom*, "*Lioconcha hieroglyphica*: large triangles with a fine structure. The simulation is based on a two inhibitor model . . . plus a [pigment-cell] hormone for simultaneous termination of many triangles. Oscillations cause the fine structure of triangles." [From *The Algorithmic Beauty of Sea Shells*]

chemicals could be used as a model for the generation of shell patterns Ermentrout developed a model using a neural net. Because the pigment-excreting cells in the mantle of a mollusk are under neural control, it is plausible to approach the problem by way of well-understood neural mechanisms that activate pigment synthesis locally while inhibiting it laterally. Formally, Ermentrout's models and results are similar to those described by Meinhardt, a feature of neural net models he points out. Thus, the main result and interest of *The Algorithmic Beauty of Sea Shells* is to show how a very large range of complex and beautiful patterns can be understood by an elegant insight. Although nearly 200 pages of text on this one topic may seem a bit much for some readers, the book is clearly written with many appeals to common experience for beginners. And it helps that the modeled subjects are beautiful. In effect a celebration of the power of analytical thinking, the book would make a splendid gift for anyone with an interest in how a mathematical model is designed and executed as well as anyone interested in the subject matter itself.

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Vignettes: Veiled Presences

Men's first names are designated by initials (*e.g.* Smith, J. D.) except for knights and baronets or where it is necessary to distinguish between two men with the same initials and surname, at the same institution; or, in the case of non-Western names of two or more elements none of which is abbreviated.

Women's names are normally indicated by the inclusion in full of one first name (unless the university, department or individual has requested otherwise), any other first names being represented by initials only (*e.g.* Smith, Mary J.). The word "Mrs." may be included in the entries for married women, but "Miss" is omitted when a first name is given in full, unless it is likely to be unfamiliar as such to English-speaking readers.

Where, as a matter of policy, an institution does not wish to differentiate between male and female staff, a note to that effect is printed at the head of its chapter.

—"Notes on the University Chapters" in *Commonwealth Universities Yearbook: A Directory to the Universities of the Commonwealth and the Handbook of Their Association*, 1994 edition, volume 1 (Association of Commonwealth Universities)

Counting heads in University departments . . . is by no means a straightforward exercise these days.

—*Deirdre O'Sullivan*, in *Equity Issues for Women in Archaeology* (Margaret C. Nelson, Sarah M. Nelson, and Alison Wylie, Eds.; American Anthropological Association)

Books Received

An Anthropologist on Mars. Seven Paradoxical Tales. Oliver Sacks. Knopf, New York, 1995. xx, 330 pp., illus., + plates. $24 or $C35.

Arithmetic of Diagonal Hypersurfaces over Finite Fields. Fernando Q. Gouvêa and Noriko Yui. Cambridge University Press, New York, 1995. xii, 168 pp., illus. Paper, $32.95. London Mathematical Society Lecture Note, 209.

Behavioral Approaches for Children and Adolescents. Challenges for the Next Century. Henck P. J. G. van Bilsen, Philip C. Kendall, and Jan H. Slavenburg, Eds. Plenum, New York, 1995. viii, 176 pp., illus. $69.50. From a conference, Rotterdam, The Netherlands, July, 1994.

Bose-Einstein Condensation. A. Griffin, D. W. Snoke, and S. Stringari, Eds. Cambridge University Press, New York, 1995. xiv, 602 pp., illus. $79.95. Based on a workshop, Levico Terme, Italy, May-June 1993.

The Chemistry of Metal CVD. Toivo T. Kodas and Mark J. Hampden-Smith, Eds. VCH, New York, 1994. xxiv, 530 pp., illus. $135.

College Algebra with Graphics and Problem Solving. Karl J. Smith. Brooks/Cole (Wadsworth), Pacific Grove, CA, 1994. xvi, 666 pp., illus. $56.25.

Environmental Chemistry of the Heavy Elements. Hydrido and Organo Compounds. John S. Thayer. VCH, New York, 1995. xii, 145 pp., illus. $65.

Enzymology and Molecular Biology of Carbonyl Metabolism 5. Henry Weiner, Roger S. Holmes, and Bendicht Wermuth, Eds. Plenum, New York, 1995. xii, 442 pp., illus. $120. Advances in Experimental Medicine and Biology, vol. 372. From a workshop, Palmerston North, New Zealand, July 1994.

Expanding Archaeology. James M. Skibo, William H. Walker, and Axel E. Nielsen, Eds. University of Utah Press, Salt Lake City, 1995. viii, 256 pp., illus. $40.

The Giant Planet Jupiter. John H. Rogers. Cambridge University Press, New York, 1995. x, 418 pp., illus., + plates. $89.95. Practical Astronomy Handbook, 6.

The Great Human Diasporas. The History of Diversity and Evolution. Luigi Luca Cavalli-Sforza and Francesco Cavalli-Sforza. Addison-Wesley, Reading, MA, 1995. xvi, 300 pp., illus. $27.50. Translated from the Italian edition (Milan, 1993) by Sarah Thorne.

A History of Hypnotism. Alan Gauld. Cambridge University Press, New York, 1995. xx, 738 pp., illus. $120; paper, $34.95. Reprint, 1992 ed.

A History of Life on Earth. Understanding Our Planet's Past. Jon Erickson. Facts on File, New York, 1995. xii, 244 pp., illus. $24.95. Changing Earth.

Information Seeking in Electronic Environments. Gary Marchionini. Cambridge University Press, New York, 1995. xii, 224 pp., illus. $49.95. Cambridge Series on Human-Computer Interaction, 9.

Introduction to Environmental Impact Assessment. Principles and Procedures, Process, Practice and Prospects. John Glasson, Riki Therivel, and Andrew Chadwick. UCL, London, 1994 (U.S. distributor, Taylor and Francis, Bristol, PA). x, 342 pp., illus. $75; paper, $27.50.

Introduction to Geophysical Fluid Dynamics. Benoit Cushman-Roisin. Prentice Hall, Englewood Cliffs, NJ, 1994. xvi, 320 pp., illus. $60.

The Mangle of Practice. Time, Agency, and Science. Andrew Pickering. University of Chicago Press, Chicago, 1995. xiv, 281 pp., illus. $45 or £35.95; paper, $17.95 or £14.25.

Microbiology and Immunology Casebook. James T. Barrett. Little Brown, New York, 1995. x, 262 pp. Paper, $17.95.

Mitochondria. DNA, Proteins and Disease. V. Darley-Usmar and A. H. V. Schapira, Eds. Portland, Chapel Hill, NC, 1994. xii, 286 pp., illus. $80 or £50. Portland Press Research Monograph, 5.

Nature's Numbers. The Unreal Reality of Mathematical Imagination. Ian Stewart. BasicBooks, New York, 1995. xii, 164 pp., illus. $20. Science Masters.

The Petkau Effect. The Devastating Effect of Nuclear Radiation on Human Health and the Environment. Ralph Graeub. 2nd ed. Four Walls Eight Windows, New York, 1994. xxvi, 251 pp., illus. Paper, $14.95. Translated from the German edition (Bern, 1990) by Phil Hill.

Photodissociation Dynamics. Spectroscopy and Fragmentation of Small Polyatomic Molecules. Reinhard Schinke. Cambridge University Press, New York, 1995. xvi, 417 pp., illus. $100; paper, $39.95. Cambridge Monographs on Atomic, Molecular, and Chemical Physics, 1.

The Physical Principles of Magneto-optical Recording. Masud Mansuripur. Cambridge University Press, New York, 1995. xx, 756 pp., illus. $99.95.

Physics for Geologists. Richard E. Chapman. UCL, London, 1995 (U.S. distributor, Taylor and Francis, Bristol, PA). xvi, 143 pp., illus. Paper, $24.95.

Quantum Chemistry Workbook. Basic Concepts and Procedures in the Theory of the Electronic Structure of Matter. Jean-Louis Calais. Wiley, New York, 1994. xii, 204 pp. Paper, $39.95.

Scientific Visualization. Advances and Challenges. L. Rosenblum *et al.*, Eds. Academic Press, San Diego, 1994. xxiv, 532 pp., illus. $35.

Self-Efficacy, Adaption, and Adjustment. Theory, Research, and Application. James E. Maddux, Ed. Plenum, New York, 1995. xviii, 395 pp., illus. $54.50. Plenum Series in Social/Clinical Psychology.

Thermodynamics of Small Systems. Parts I and II. Terrell L. Hill. Dover, New York, 1994. xii, 210 pp., illus. Paper, $10.95. Reprint, 1963-64 ed.

Publishers' Addresses

Below is information about how to direct orders for books reviewed in this issue. A fuller list of addresses of publishers represented in *Science* appears in the issue of 26 May 1995, page 1220.

Cambridge University Press, 110 Midland Ave., Port Chester, NY 10573–4930. Phone: 800-872-7423; 914-937-9600. Fax: 914-937-4712.

Springer-Verlag New York Inc., 333 Meadowlands Parkway, Secaucus, NJ 07096. Phone: 800-777-4643; 201-348-4033. Fax: 201-348-4505.