book is a nice collection of the latest observations, calculations, and ideas on isolated pulsars.

Fred Seward
Harvard-Smithsonian Center for Astrophysics, Cambridge, MA 02138

Homeostatic Conditioning

Learning and Physiological Regulation. BARRY R. DWORKIN. University of Chicago Press, Chicago, 1993. xvi, 215 pp., illus. $23.95 or £19.25. John D. and Catherine T. MacArthur Foundation Series on Mental Health and Development.

For a rat, a shot of alcohol is a chilling experience, but only at first. One cubic centimeter of ethanol dilates the rat's blood vessels, increasing thermal conductance between core and periphery, so that in a typical 23°C environment the animal rapidly loses body heat. However, after a few of these chilling experiences, anticipatory thermoregulatory mechanisms kick in when the shot of alcohol seems imminent, generating heat to offset the anticipated loss. Thus the animal's thermal response to alcohol shows what a pharmacologist would call tolerance. The drop in body temperature becomes less pronounced with each successive administration of alcohol.

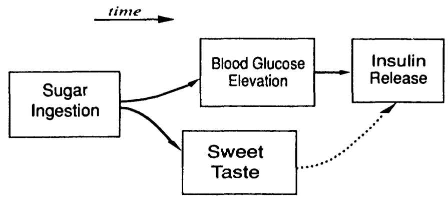
Experiment shows that this tolerance is the result of classical conditioning to stimuli associated with the administration of alcohol. The experimenter first administers alcohol under one set of circumstances and saline solution under different conditions to the same animal and then switches substances. When alcohol is injected under circumstances initially associated with it there is no hypothermic response, indicating tolerance, but when alcohol is injected into the same animal under the circumstances associated with the saline solution, there is a full-blown hypothermic response. Moreover, when the saline solution is injected under circumstances associated with alcohol, there is a strong hyperthermic response. The rat that expects alcohol but gets the saline solution generates heat to offset an anticipated loss that does not materialize.

The anticipatory thermoregulatory response illustrates the thesis of Barry Dworkin in *Learning and Physiological Regulation*, in which he brings together two historically disparate experimental and theoretical traditions—the study of learning and the study of regulatory mechanisms. His goal is to get students of learning to think about classical and instrumental conditioning in a regulatory context and to get students of regulatory mechanisms to appreciate the large role that learning plays in regulation. In the process, he gives a sympathetic review of the often ignored Russian work on the conditioning of interoceptive reflexes.

Dworkin brings into sharp focus a major unsolved problem in regulatory physiology: how the brain achieves accurate long-term regulation of the physiological state in the apparent absence of transducers capable of a prolonged steady-state response. Many physiological variables are held within narrow limits for most of an animal's lifetime. To hold constant such vital internal factors as blood pressure, body temperature, pH, carbon dioxide concentration, salinity, nutrient levels, and so on, the neuroendocrine system receives signals from specialized interoceptive sensors. Many such interoceptors have been identified and studied experimentally. Without fail—as Dworkin goes to some lengths to document—they have one serious shortcoming: they cannot signal drift (slow change). They adapt so rapidly that within a few seconds to, at most, a few minutes after a step change in the value of the sensed variable, the signal from the transducer is essentially zero. Imagine trying to design an effective heating and air-conditioning system when all available thermometers read zero regardless of the actual temperature, provided only that the actual temperature has remained steady for the last few minutes.

Dworkin thinks that instrumental conditioning mechanisms may offer a solution to the problem of how regulatory mechanisms cope with this serious shortcoming in transducer characteristics. The idea is that all the transducers need to do is signal "mistakes" in the patterns of efferent regulatory neural signals. Mistakes are efferent patterns that drive regulated variables outside the bounds of what local bufferlike, non-neural tissue reactions can manage. The mistake signals act the way punishers in instrumental conditioning do; they decrease the frequency of the kinds of outputs that generate them (according to the law of effect, as it applies to punishers). These ideas are developed only in schematic form in the final chapter of the book. It is hard to judge whether they offer serious prospects for resolving the paradox posed by adapting transducers in regulatory pathways.

In contrast, Dworkin devotes two earlier chapters to a more rigorous, mathematical development of the idea that classical conditioning endows regulatory systems with what amounts to anticipatory control. Anticipatory control is a much more sophisticated form of control than that provided by the simple servomechanisms taught in introductory courses in regulatory physiology. Anticipatory regulators extrapolate future challenges and take countermeasures before those challenges materialize. Yet Dworkin's development of this concept is awkward, relying on unconventional discrete time-bin mathematics and equally unconventional diagrams intended to illustrate his arguably more intuitive but certainly less mathematically felicitous approach to the problem of mathematically characterizing the behavior of mechanisms whose outputs and inputs are both continuous functions of time.



"Conditioned insulin release. The act of eating candy is a common example of this paradigm. Candy contains sucrose, which tastes sweet and when digested and absorbed raises blood glucose, eventually releasing insulin. It goes first into the mouth and from there into the stomach; so the sensory stimulus of a sweet taste automatically precedes the physiological stimulus of elevated blood glucose. After consuming many pieces of candy, a sweet taste alone will release insulin." [From *Learning and Physiological Regulation*]

Serious students of regulatory physiology will want to read this book. Students of conditioning may also find it thought-provoking, despite what many will think a dated and simplistic treatment of classical and instrumental conditioning.

C. R. Gallistel
Department of Psychology, University of California, Los Angeles, CA 90024–1563

Books Received

Advanced Topics in Materials Science and Engineering. J. L. Morán-López and J. M. Sanchez, Eds. Plenum, New York, 1993. x, 356 pp., illus. $95. From a symposium, Ixtapa, Guerrero, Mexico, Sept. 1991.

Advances in Economic Theory. Vol. 1. Jean-Jacques Laffont, Ed. Cambridge University Press, New York, 1993. x, 327 pp., illus. $54.95. Econometric Society Monographs, no. 20. From symposia, Barcelona, Aug. 1990.

Aerosol-Cloud-Climate Interactions. Peter V. Hobbs, Ed. Academic, San Diego, CA, 1993. xii, 233 pp., illus. $65. International Geophysics Series, vol. 54.

Agricultural Research in the Northeastern United States. Critical Review and Future Perspectives. J. T. Sims, Ed. American Society of Agronomy, Madison,