# books

## Assessing the biological response to physical processes

### Principles of Environmental Physics

**J. L. Monteith**
241 pp. Elsevier, New York, 1973. $20.00

*Reviewed by William E. Reifsnyder*

This is a deceptively small book. In 215 pages of text, John Monteith covers the developing field of environmental physics in an extraordinarily comprehensive and useful way. It may not seem to be much of a compliment to say that this is the best book in its field when the number of competitors is small. However, it would be at the top of the list even with very stiff competition.

It is a book on energy exchange and details the ways in which energy is exchanged between the biological surfaces and the environment. The term "biological surfaces" is used consciously for although Monteith is primarily known as an agricultural physicist, he does not neglect the environmental physics of animals and man. If there is one area that is lacking it is that of forest meteorology, but that results at least in part from the paucity of analytical and observational research.

The book starts out with a brief review of the physics of energy-transfer processes. The radiation environment of biological entities is covered in satisfying detail. In particular the section on radiation geometry presents enough information on shape factors to permit the calculation of radiant-energy exchange with many simple biological objects. The section is replete with useful equations and worked-out examples. Indeed, this is a commendable feature of the entire book. Monteith not only presents the theoretical development of the energy-transfer equations, but also presents practical methods of analyzing and computing energy exchanges and balances.

An engineering approach is used in the treatment of transfer in the atmospheric-boundary layer. The usefulness of nondimensional groups such as the Nusselt number, Prandtl number and the Grashof number in estimating heat transfer by convection is well illustrated. A criticism, though, of the use of these and other nondimensional groups in the book is that the treatment is so highly condensed. Students who have been introduced to these groups in engineering courses will follow the development easily. Those without this background may find the going rough indeed. However, the basic information is there and the diligent reader should not be overwhelmed.

Mass transfer by molecular and turbulent processes is also treated through the use of nondimensional groups. Especially useful and clear is Monteith's discussion of mass transfer through stomata, the pores on leaves through which water and carbon dioxide are exchanged with leaf surfaces. Somewhat more cursory is the analysis of heat transfer by conduction, although the basic principles are all there. In considering conduction through skin, fur and clothing, Monteith takes a well deserved pot-shot at the animal and human physiologists who have adopted curious units such as the "met" and the "clo." I agree with him that "specialized units of this type have few merits and tend to separate a subject from other related branches of science." Monteith has taken a big step in attempting to bring these units and concepts under the umbrella of more conventional physical units.

Monteith has also developed a useful graphical method of analyzing the heat balance of natural surfaces that clearly shows the relative importance of the various modes of heat transfer when applied to specific organisms in various sets of environmental conditions. Finally, he discusses the measurement and interpretation of heat fluxes in stands of vegetation, and briefly discusses models relating energy flux to crop microclimate and productivity.

Many textbook authors are content with summarizing what is known in a particular field or group of fields. Monteith has commendably carried this one step further by producing a true synthesis of heat-transfer information for all types of biological surfaces and presenting this information in a way that is both physically understandable and practically useful.

According to the author, the book "was written partly to provide undergraduates in the biological sciences with a foundation for more advanced study," but I think that many biologists would find it hard going. At the minimum, a background in classical physics, engineering heat- and mass-transfer and calculus are essential. More and more undergraduate biologists are studying these subjects; even more should. With this background, Monteith's book can be an exciting introduction to the application of these principles to important biological and ecological problems. I intend to use it as the basic text in a graduate course in micrometeorology for biologists and ecologists, for which there has been no satisfactory single text heretofore. My only hesitation is in requiring a text that even in these days of inflation appears to place a financial burden on students. However, considering the quality of the work, I have no alternative. Monteith is to be congratulated on producing such a fine book.

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## Buoyancy Effects in Fluids

**J. S. Turner**
367 pp. Cambridge U. P., New York, 1973. $29.50

A lesson taught by Ludwig Prandtl early in this century is that small causes in fluids (such as feeble viscosity) can have pronounced effects (the boundary layer). The subject of Stewart Turner's advanced research monograph is another case in point. Here we find a fascinating array of phenomena originating wholly from the frequently neglected Archimedean force in fluids. Attention is restricted to situations where buoyancy arises solely from the vertical acceleration of gravity (presumed large compared to the acceleration of fluid particles) acting on small deviations of density away from a stratified hydrostatic equilibrium state of an incompressible, nonrotating fluid. The density variations drive the fluid contortions of interest and are continually being altered by those motions. The smallness assumption need not imply linearized dynamics; indeed many essentially nonlinear phenomena are treated, such as solitary interval gravity waves, turbulent shear flows and high Raleigh-number thermal convection.

This branch of fluid dynamics has undergone massive development in this century. Important applications in meteorology, oceanography, geophysics and hydraulics provide strong motivation for much of the work, but also contribute to a maze of literature. As a senior worker well known for his beautiful experimental work, J. S. Turner, assistant director of research in fluid mechanics at Cambridge University, is a capable guide through the thickets of nearly 500 references. Two dozen fine photographic plates reveal the true flavor of the material covered.

The first half of the book deals with flows stemming from undisturbed states that are statically stable (that is, the fluid is "bottom heavy"). A basic property of such a state is the fluid's ability to sustain internal gravity waves whose restoring force is the buoyancy associated with the equilibrium stable stratification. Following a treatment of infinitesimal waves and an especially interesting coverage of finite amplitude effects, Turner proceeds to the instabilities of such laminar shear flows and their evolution into turbulence. He develops a useful scheme to classify a variety of mixing processes in stably stratified fluids according to the location (that is, at a boundary or internally) and dynamics of the source of energy generating the turbulence.

When the undisturbed equilibrium state is gravitationally unstable ("top heavy"), a host of convective flows can ensue. Turner first treats the isolated convective elements themselves (plumes and thermals) using the entrainment assumption, before covering convection from surface distributions of heat sources. The novel convective effects, such as "salt fingers," accom-