and methods of solving protein structure clearly distinguish this volume from a biochemistry textbook. The book also provides a good overview and references for graduate courses on structure and function of macromolecules, although it does not contain details of the chemistry or stereochemistry of interactions that might be desirable for such a graduate course. It should be a very important supplementary textbook, strongly recommended for any undergraduate, premedical, or postgraduate biochemistry course.

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Turbulence Theory

The Physics of Fluid Turbulence. W. D. McComb. Clarendon (Oxford University Press), New York, 1990. xxiv, 572 pp., illus. $150. Oxford Engineering Science Series, 25.

The Navier-Stokes equations are not linear, with the consequence that an equation for a given statistical moment contains the next higher moment. This "closure problem" has plagued turbulence theory since its beginning, with many suggestions made but none of them satisfactory. In 1959 Robert Kraichnan suggested borrowing from quantum field theory the renormalized perturbation methods (complete with Feynman diagrams) to close the turbulent moment hierarchy. He was followed by other pioneers (Wyld, Edwards, and Herring) and then by many more. These methods have been followed by simplified techniques (the test field model) and by the distantly related renormalization group method, also borrowed from quantum field theory.

With all these methods lumped together under a single heading, it is fair to say that they offer the only approach to turbulence that can be called a general dynamical theory (as opposed to a phenomenological one), although dynamical systems theory has recently made some progress. (Approaches like multifractals must still be regarded as statistical models.) It was thought for some time that renormalized perturbation methods were approximations that could lead to successive improvements, but it was finally realized that they were more in the nature of very sophisticated dynamical models. The approach has been conceptually very useful in understanding interactions of various wavenumbers and is actually capable of calculating a few things more or less from first principles. It has been useful in plasma physics. Nevertheless, it has not fulfilled its initial promise, primarily because, when it is applied to a shear flow at high Reynolds number, the computations are more costly than would be a direct or large-eddy numerical simulation. People are working on simplifications (such as the test field model) that would make the problem more tractable.

Approximately a third of this book is devoted to these renormalization techniques. The material is quite accessible, thorough, and complete. It is one of the few places to which a student could be referred for instruction in this subject, the others being D. C. Leslie's *Developments in the Theory of Turbulence* (Oxford University Press; paperback edition, 1989), which does not touch on renormalization group methods, and a few pages in M. Lesieur's excellent *Turbulence in Fluids* (Kluwer; 2nd edition, 1991).

McComb's great advantage over Leslie's older and rather monodisperse book is found in the other two-thirds of the volume. Here McComb gives a brief but fairly complete introduction to the semiempirical approach to turbulence and to the classical statistical approach, as well as a bit on measurement techniques, a bit on intermittency, a section on numerical simulation, a section on statistical-mechanical approaches, and a section each on coherent structures, the Lagrangian and Eulerian views of turbulent diffusion, and non-Newtonian fluid turbulence. In the sections on perturbation approaches, McComb is speaking from the heart, but on the other subjects, he is no more than an intelligent and well-informed reporter. Nevertheless, a student who actually reads this book will be moderately well informed also, which is all we can hope for. There is no question that this is a physicists' book that probably will be useful only to those who are not daunted by a great deal of formal manipulation.

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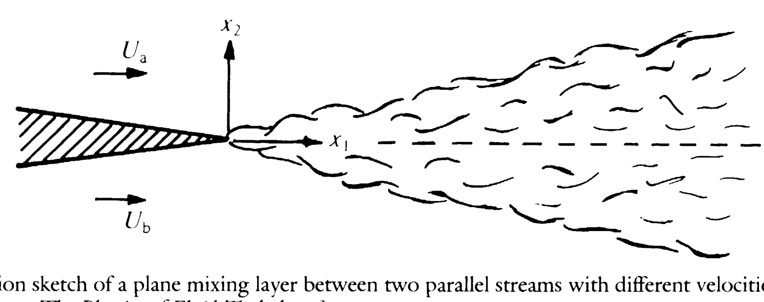

"Definition sketch of a plane mixing layer between two parallel streams with different velocities U_a and U_b." [From *The Physics of Fluid Turbulence*]

Biogeochemical Cycles

Biogeochemistry. An Analysis of Global Change. WILLIAM H. SCHLESINGER. Academic Press, San Diego, CA, 1991. xii, 443 pp., illus. Paper, $39.95.

Biogeochemistry deals with the interaction between life and its chemical environment. Biogeochemical cycles, with which this book is principally concerned, describe the processes that control the composition of the environment, atmosphere, and natural waters and the processes by which the composition can change. The term "cycles" refers to the fact that much of the movement of matter is cyclical; photosynthesis, for example, transfers carbon from the atmosphere to the biota while decay transfers the carbon from the biota back to the atmosphere at an essentially equal rate. Carbon therefore cycles between atmosphere and biota. The methodology for the study of the biogeochemical aspects of global change is based largely on considerations of conservation of matter. The global environment is divided into a number of reservoirs appropriate to the problem at hand. These reservoirs might be ocean, atmosphere, and global biota, for example. The amounts of the element of interest in each of the reservoirs are established by observation, along with the rates at which material is transferred between reservoirs. Then, at least in principle, the evolution of the system can be calculated by saying that the amount of material in each reservoir changes with time at a rate equal to the difference between the rates at which material is added to the reservoir (the sources) and the rates at which material is removed from the reservoir (the sinks). This approach to the study of biogeochemical cycles is well developed in this book, with chapters devoted to the global cycles of water, carbon, nitrogen and phosphorus, and sulfur. In addition, the book sets the stage for the consideration of these global cycles with chapters on the atmosphere, lithosphere, terrestrial biosphere, biogeochemical cycling on land, in freshwater wetlands and lakes, in rivers and estuaries, and in the sea. The treatment is comprehensive and detailed. The book contains a wealth of useful information in the form of tables, diagrams, and text. There are approx-