Preface

This book is about fluids containing polyatomic structures such as polymer molecules or colloidal grains. Such structured fluids have come to be known as soft condensed matter. The book takes a scaling approach, following de Gennes's important monograph *Scaling Concepts in Polymer Physics*. My purpose is to provide a unified, pedagogical introduction to soft-matter phenomena that embodies this scaling approach. The book focusses on how to account in the simplest way for the distinctive length, time and energy scales that characterize each phenomenon. This approach allows unity and simplicity, but it provides only an initial glimpse into the rich phenomena and science to be found in soft condensed matter. Notably, I omit an important aspect of soft matter: the broken symmetry of the liquid crystalline state and the distinctive responses and structures that arise from it. This realm of soft matter has benefited greatly from the modern tools of differential geometry and field theory, as discussed elegantly in the advanced text *Principles of Condensed Matter Physics* by Paul Chaikin and Tom Lubensky (Cambridge, 1995).

The book began life in the late eighties as a joint venture with Phil Pincus of the University of California, Santa Barbara. The chapters developed over several cycles of teaching a course on structured fluids at Chicago. The intended audience is the advanced undergraduate in physical science or engineering who is comfortable with elementary physics and has seen elementary statistical mechanics. The needed knowledge of physics is at the level of *eg.* D. Halliday and R. Resnick's *Fundamentals of Physics* (New York, Wiley 2000). I assume the student has seen statistical physics at the level of Reif's book, the second item of the list below. A working knowledge of Fourier transformation will also be helpful.

Important conceptual points are illustrated by problems interspersed through the text. The serious student should work these problems since the logical development remains incomplete without them. Almost all of the problems have been assigned, graded, and refined at least once. The book also includes a number of suggested experimental projects using household materials. These are intended to show concretely the principles discussed. They also give the student a sense of how well the idealizations treated in the book apply to real liquids. Students in the structured fluids course were required to do one of these projects or some other project of their own devising. The projects are meant to open a line of inquiry; only some have been tested, and the student may well find that great modifications are needed to make them work. To guide the student to further information, the book includes references to more detailed work. I've tried to suggest sources in each major subject area. In some cases I've cited primary journal articles. but these references are far from being thorough or balanced.

In teaching the course, I found that the text contains too much material to be covered in a one-quarter term with 27 class hours. It could probably be covered rapidly in a one-semester course.

In learning from this book, there are several useful reference works to keep in mind. The first and most important is De gennes' monograph on polymer physics, Item 1 on the list below. Polymers serve as the paradigmatic system in the book. Most of the ideas are be developed using polymers as an example, then applied to other structured fluids. For further depth or clarification of these ideas, De gennes' book is the best single source of which we are aware. The subject depends heavily on ideas of statistical physics. The book develops all the needed ideas within the text and aims to keep their number to a minimum. Still, more explanation or depth on statistical physics may be helpful; a good source is Reif's book cited in Item 2. For the discussion of colloids and surfactants, Item 3 is useful. This practical book by Jacob Israelachvili is about liquids generally but contains much information about colloids and surfactants. For collective properties of surfactant assemblies, Sam Safran's book (Item 4) is useful.

1. P-G de gennes, *Scaling Concepts in Polymer Physics*, Cornell, Ithaca NY (1979).
2. F. Reif, *Fundamentals of Statistical and Thermal Physics*, McGraw-Hill (1965).
3. Jacob N. Israelachvili, *Intermolecular and surface forces*, 2nd ed. (London ; San Diego, CA : Academic Press, 1991)
4. Samuel A. Safran, *Statistical thermodynamics of surfaces, interfaces, and membranes* (Reading, Mass. : Addison-Wesley Pub., 1994).

The reader should know about other classic and recent works that cover the same material. The polymer physics material in Chapters III and IV is well covered by other textbooks and monographs. Two of the best known are Paul J. Flory's *Statistical Mechanics of Chain Molecules* (New York, Interscience Publishers 1969) and Charles Tanford's *Physical Chemistry of Macromolecules* (New York, Wiley 1961) . There is also an important property handbook: *Polymer Handbook*, 4th edition, by J. Brandrup, E. H. Immergut and E. A. Grulke (New York, Wiley, 1999). An important monograph written from a statistical physicist's point of view is *Polymers in Solution* by G. Jannink and J. Des Cloizeaux (Oxford, Clarendon press, 1992). Another monograph gives an authoritative treatment of polymer motions. It is *The Theory of Polymer Dynamics* by Masao Doi and S. F. Edwards (New York, Oxford University Press, 1986). Two recent textbooks offer a pedagogical treatment of polymers: *Statistical physics of Macromolecules* by A. Yu. Grossberg and A. R. Khokhlov (New York, AIP Press, 1994), and *Polymer Physics* by M. Rubinstein, R. H. Colby (New York, Oxford University Press, in press). A recent text covering a variety of structured fluids is Ronald G. Larson's *The structure and rheology of complex fluids* (New York, Oxford University Press, 1999). It is more advanced and more comprehensive than this book. Richard A. L. Jones's new text *Soft Condensed Matter* (Oxford, 2002), is similar to the present book in scope and level.

By now the efforts of several people have improved the text greatly. The book owes much to the generations of students who took the course, read early drafts, and forced me to be more clear. Arlette Baljon, Alfred Liu, Keith Bradley, Joe Plewa and other students weeded out errors and confusing statements in the text. Jung-ren Huang improved every chapter by his close reading and thoughtful suggestions. He also compiled the data for the big table of semidilute universal ratios in that chapter. Olgica Bakajin did the simulation to make the dilation symmetry figure in the appendix of Chapter III. Sidney Nagel and other colleagues at the James Franck Institute took a lively interest in the course, and the book benefited from their discussions and support. Oxford editor Bob Rodgers provided early encouragement and obtained several very useful reviews of an early draft of the book. Seven other reviewers looked at the completed book last year and many improvements were made in response to their wise suggestions. Phil Pincus inspired this entire project and wrote the first draft of the Colloids chapter. He also spent many hours over several collaborative visits to bring the book along. The book would not exist without the support and encouragement of my wife Molly.

——T. A. Witten, Chicago, May 2003