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What is rheology anyway?

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by Faith A. Morrison

When the hotel clerk at a Society of Rheology meeting asks me what rheology is, I have a ready answer I could use: "Rheology is the study of deformation and flow." This is true, but not an answer that would usually trigger a light-bulb moment for the friendly staff member.

Instead, I say, "Rheology is the study of the flow of materials that behave in an interesting or unusual manner. Oil and water flow in familiar, normal ways, whereas mayonnaise, peanut butter, chocolate, bread dough, and Silly Putty flow in complex and unusual ways. In rheology, we study the flows of unusual materials."

I have even had the experience of explaining rheology to a guest at a wedding reception. "Oh, you're writing a book," says Dipankar, a theater director and friend of the bride. "What is it about?"

"It's a college textbook called Understanding Rheology." Then came the predictable question. "What's rheology?"

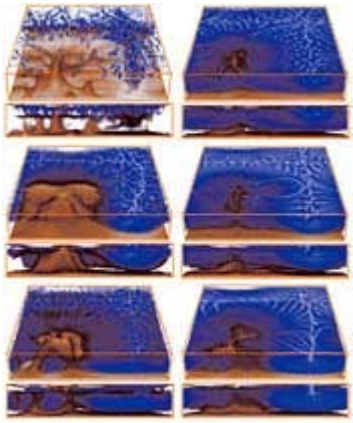
Because we had time before the dancing resumed and Dipankar appeared to be truly interested, I went beyond the desk-clerk version and explained a bit more about rheology. " You know how, when you open a partly used jar of mayonnaise, the top surface retains the shape created by the last person who made a sandwich?"

"True," said Dipankar.

"Well, compare that observation with the behavior of honey. The top surface of honey in a jar is always smooth. Within a few seconds of serving yourself from a honey jar, the surface is flat again. Honey is able to flow and become flat quite rapidly, while the mayo, even after months, fails to flow, and it retains the last shape carved into it by a knife."

"That is odd," Dipankar concurred. "What's the difference between mayo and honey? If anything, honey seems thicker to me than mayonnaise, so the honey should have a harder time flowing than the mayo."

"Good observation. You've just noticed a key point about studying unusual flow behavior. Normal fluids can be different in the sense that some are thicker than others; some fluids have higher viscosities than others. But other than having different viscosities, all normal or Newtonian fluids—air, water, honey—follow the same scientific laws. On the other hand, some fluids do not follow Newtonian flow laws. These non- Newtonian fluids—for example, mayo, paint, molten plastics, and foams— behave in a wide variety of ways."



The dynamics of convection in the Earth's mantle, with phase transitions, to a depth of 2,880 km, is numerically simulated using a supercomputer and combining results from mineral physics, tomography, and mantle convection.
(David Yuen, Department of Geology, University of Minnesota Twin Cities Campus)

Anyone who has cooked, baked, or played in a sandbox or bubble bath has experimented with rheology. Discussing the deformation of food is a way to introduce the subject of rheology, but the rheology of food is only one subfield of the broad science of rheology. Flows of elastic solutions and of those containing long-chain polymers, including coatings, as well as flows in extruders, molds, and other processing equipment, dominate rheology today. Many industrial problems involve rheological concerns. These include the need to understand the transport of foams and yield-stress fluids in oil drilling and enhanced oil recovery, and the importance of understanding the behavior of biological macromolecules in microfluidic devices for lab-on-a-chip applications. Geoscientists invoke rheology in studies of volcanism and the convection through Earth's mantle and outer core (see figure, page 30).

The word rheology comes from rheo, from the Greek word for flow, and –ology, meaning study of. Scientists who study the mathematical relationships that describe the behavior of non-Newtonian fluids are called rheologists, and 1,800 of them from around the world are members of The Society of Rheology (SOR), a founding member society of the American Institute of Physics. The Society was officially formed on Dec. 9, 1929, the outgrowth of a burgeoning interest in the behavior of colloidal materials, including the flow behavior of newly discovered synthetic rubbers and polymers.

The Society's core mission is the advancement of rheology and its applications, and to that end, it sponsors yearly meetings and publishes the Journal of Rheology and the Rheology Bulletin. The journal, a peerreviewed scholarly publication, appears 6 times a year. The Rheology Bulletin is a twicea- year newsletter that keeps SOR members informed of Society activities and of other topics of interest to rheologists.

The Society is governed by an executive committee and led by a president, vice president, and other officers, including the editor of the Journal of Rheology. SOR has always drawn its leadership from the highest ranks of rheological research. The current president is Susan J. Muller, professor of chemical engineering at the University of California, Berkeley, and the vice president is Andrew M. Kraynik of Sandia National Laboratories (Albuquerque, NM). Morton M. Denn, the editor of the *Journal of Rheology* for the last eight years, is Albert Einstein Professor and director of the Benjamin Levich Institute for Physico-Chemical Hydrodynamics at the City College of the City University of New York.

Everything Flows

The Greek letters on the hourglass logo of The Society of Rheology— παντα ρει (sometimes pronounced phonetically " panta rei")—may be translated "everything flows." This phrase (or philosophy) is attributed to the Greek philosopher Heraclitus of Ephesus (536–470 BCE) and is taken from the more complete quote: "Everything flows and nothing abides; everything gives way and nothing stays fixed." The Society motto was suggested by Eugene Cook Bingham, the father of SOR, at the time of the Society's founding in 1929, and it reflects the field of study of rheology — deformation and flow, no matter how unlikely. For example, we are used to the concept of fluid flow, but solids also flow, under the right conditions of time and stress. See also Reiner, M. The Deborah Number. *Physics Today*, January 1964, p. 62.

SOR, an all-volunteer society, has always attracted members interested in maintaining the high quality of its journal and of its activities. The Society's 75th annual meeting in Pittsburgh on Oct. 12–16, 2003, attracted 370 attendees. The 76th annual meeting will be held in February 2005. SOR annual meetings are held in October except during years of the International Congress of Rheology, which will convene this year on Aug. 22–27 in Seoul, South Korea. SOR will hold two annual meetings in 2005, on Feb. 13–17 in Lubbock, Texas, and Oct. 16–20 in Vancouver, British Columbia. The Society keeps its annual meeting fees low (at Pittsburgh, members paid $125 with early registration, and students paid $60), and by long-standing tradition, industrial friends sponsor Society receptions throughout the meeting.

Society membership is open to anyone whose work and interests lie in the field of rheology. If you are fascinated by gooey, sticky, stretchy substances, The Society of Rheology is for you. Annual dues are $40 per year for regular members and $25 for students. All members receive the Journal of Rheology, the Rheology Bulletin, and AIP publications such as Physics Today, and they have access to the members-only portions of the Society Web page, which includes a searchable membership database. The Web site also contains full information about joining SOR, news, and meeting announcements.

Biography

Faith A. Morrison is an associate professor of chemical engineering at Michigan Technological University in Houghton and the author of *Understanding Rheology* (Oxford University Press, 2001, 560 pp.). She is the editor of the *Rheology Bulletin* and a member of the SOR membership committee.