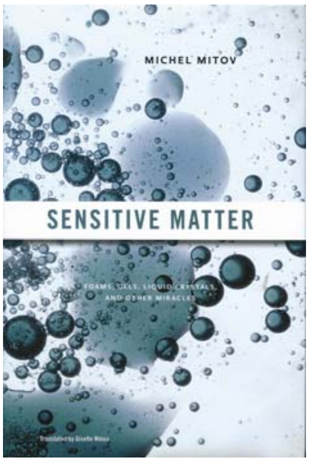
address topics which are entirely in the policy domain, are interesting to read. But one has to keep in mind that the practices enumerated therein have worked in a particular social, economic, policy and legal context. It is doubtful if any of these can be transposed and used in a different context in India.

This is all the more so, because rigorous water accounting at a level this book describes, is yet to be introduced in India. It is pertinent to note that there is no contribution from India. Not only is there no case study, but not even a theoretical contribution. The water sector in India can be seen as divided into three clear groups. One, the technocrats and bureaucrats in the Government, who are essentially practitioners, and plan and implement water management projects. Two, academicians in hydrology or water resources departments of various institutions, who confine themselves mostly to technology, and that too purely theoretical aspects of technology. And three, a small number of civil society actors whose perception of water management rarely goes beyond rainwater harvesting and 'ancient wisdom'.

Neither of these three groups will have much use for a scholarly book on water accounting. The main users for this book will be those who develop policy. As of now India does not have any organized think-tank of water-sector professionals for generating thinking on policy issues. If and when such a think-tank is established, the thinkers would find this book an excellent starting point to develop water accounting practices for India.

CHETAN PANDIT

(Retd.) Member
(Water Planning and Projects),
Central Water Commission,
House 119, 'Sayantara' Society,
DSK Vishwa,
Pune 411 024, India
e-mail: cmpandit@yahoo.com



Sensitive Matter: Foams, Gels, Liquid Crystals and other Miracles. Michel Mitov (translated by Giselle Weiss). Harvard University Press, Cambridge, Massachusetts, USA. 2012. xvi + 184 pp. Price not mentioned.

Physicists, well known to be a breed apart, often fall prey to a Peter Pan syndrome that drives them to look for new toys to play with, new interlocking pieces of that complex jigsaw puzzle we call reality. So these children who never grew up have come up with a new discipline they call 'soft matter physics' and are stubbornly persuaded that the same basic ideas may help us understand how all these things work, from Titian's colors to the organization of life – a life that, according to Shakespeare, is made of the same 'stuff that dreams are made of'? And what could be softer than a dream?

–Roberto Piazza in 'Soft Matter: The Stuff that Dreams are Made of' (Springer Science + Business Media, 2011).

Michel Mitov's delightful book tells us why this dream is not so wild after all. Indeed, French physicist Pierre-Gilles de Gennes received the Nobel Prize in Physics in 1991 for his discovery that the methods developed for studying order phenomena in simple systems can be generalized to more complex forms of matter such as liquid crystals and polymers. The term 'soft matter' was coined by Madeleine Veyssié almost 40 years ago to describe colloidal suspensions, liquid crystals and polymers. The flow of these materials, constituted by mesoscopic aggregates held together by weak forces, is strongly correlated to their easily deformable structures.

In his Nobel lecture, de Gennes listed 'complexity' and 'flexibility' as the two distinguishing features of soft materials. The complexity arises from the organization of the supramolecular structures constituting soft matter. Mitov's book addresses the issue of flexibility – the amazing ability of soft materials to adapt to their environment (in cellular membranes, for example), their ability to create conciliation between two immiscible materials (in getting oil and water to 'mix' while making an emulsion) and their ability to completely change the properties of a material even when added in minute quantities (as in the discovery of rubber).

How do we get oil and water to mix? It is easy if we have surfactant molecules at our disposal – those schizophrenic molecules with a 'hydrophilic' (water-loving) head and a 'hydrophobic' (water-hating) tail. Surfactants orient themselves at the oil–water interfaces with their hydrophobic heads facing the oil and their hydrophilic tails facing the water. This reduces the surface energy of the emulsion droplets and stabilizes the emulsion. This principle is utilized every time we whip up some tasty mayonnaise (essentially a mixture of olive oil and egg yolk, the latter comprising about 50% water and a surfactant called lecithin). Indeed, the human liver would not function properly if the subtle balancing act of bile salts, lecithin (again!) and cholesterol is somehow disturbed.

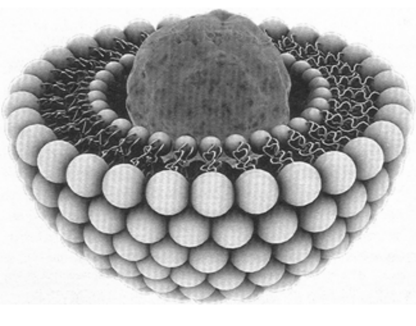
There is another way of getting molecular 'enemies' to come together – by making chemical links between two warring molecules. In this context, we are introduced to liquid crystals, constituted by elongated molecules that align when subjected to the smallest of voltages, a property that makes them essential ingredients of our computer monitors and television screens.

The discussion now turns to the role of soft materials in facilitating certain desirable changes in the properties of materials. Mitov tells us about the discovery of rubber by the Amerindians of the Amazon basin. The chemistry of rubber formation is simple – atmospheric oxygen reacts with the liquid-like latex extracted from Hevea trees to form bridges between specific points of the latex chains. The result is a solid material – rubber. We are then introduced to Charles Goodyear, the intrepid inventor, who, by sheer serendipity, ended up discovering a more stable form of rubber in 1839, used even today in rubber tyres.

Mitov next focuses on the topic of drag reduction – how the addition of minute quantities of polymers can reduce turbulence in Newtonian fluids and can effectively increase the height of a firefighter's water jet. This phenomenon is believed to stem from boundary layer effects. Mitov also uses the example of aqueous foam as yet another system where, like in emulsions, a little amount of surfactant goes a long way in stabilizing the bubbles. Foam is not always desirable, and Mitov tells us how to kill unwanted foam. The discussion moves to the human body again – Mitov tells us why breathing would not have been possible if our lungs stopped creating surfactants during each breathing cycle.

Mitov takes us back in time to discover how Egyptian scribes created stable ink from soot and water. The ink was stable only if sap from acacia trees was added to the soot–water mixture. The long polymeric sap molecules latched onto the soot particles and kept them from sedimenting. The suspension created is 'colloidal' – finely divided matter undergoing Brownian motion while dispersed in a different phase, stabilized against collapse by steric hindrance and sometimes, as in the examples of blood and clay suspensions, by electrostatic repulsions.

Mitov next forays into molecular gastronomy – he travels to Barcelona to meet celebrity chef Ferran Adria and to obtain from him the recipe of a perfect mélange – an edible foam. How does one keep it thick enough to be scooped up by a spoon, and simultaneously ensure that the mélange melts in the mouth? Mitov invokes the chemistry of colloids to explain how gelling agents work to produce that right consistency (in a very colourful analogy, he compares the percolation of a gel network to the infiltration of terrorists in civil society), how phase separation of the different constituents can be delayed and how food can be coated to seal in aromas.



Cross-sectional view of a liposome. The membrane is a bilayer of amphiphilic molecules that encapsulates an aqueous solvent containing the drug.

The last chapters of the book focus on the adaptability of soft materials. We are introduced to the cellular membrane, an intelligent form of soft matter that protects the living cell and allows the preferential transport of ions across special channels. Any disturbance in this would lead to an ion imbalance and, ultimately, death. We learn how liposomes, spherical aggregates created by amphiphilic bilayers, can trap drugs in their cores and deliver them gradually at the target in smaller, and therefore safer, doses.

Granular matter, Mitov points out, is perpetually sensitive. Dry sand, the best example of non-cohesive granular matter, can behave like a solid (we have all walked on the beach) or flow like a liquid (through our fingers, for example, under gravity). A heap of sand behaves differently from the soft materials discussed earlier. Individual grains interact dissipatively and their sizes are much larger than, say, a colloidal particle. The absence of a liquid medium results in short-ranged inter-grain interactions. Granular solids are athermal and metastable. This gives rise to bizarre consequences – forces in piles of grains are distributed, not isotropically, but through an asymmetric network of force chains. The weight of a sandpile can even be supported by the walls, which is why, unlike water and honey, the rate of flow of sand through an orifice is independent of the pressure head. This principle is used in hour glasses to keep time.

The viscosities of soft materials can change dramatically due to the applications of stresses and time-dependent strains. In the last and unarguably the most dramatic chapter, Mitov demonstrates how the science of soft matter is relevant even in religious rituals. Three times every year, the reliquary of St Janurius is carried down the streets of Naples. One of the vials in this reliquary contains dried blood – allegedly, the blood of the saint. Liquefaction of the blood before the procession ends (which has happened every time since 1389!) is a good omen. Mitov witnesses the ceremony, talks to the monsignore and concludes that the 'blood' is a thermosensitive fluid with a yield stress (i.e. it flows when a certain threshold stress is exceeded).

Soft matter is complex, but quite unavoidable! Mitov's book convinces us that we do not always need a particle accelerator to do science. Sometimes, we only need to look in the kitchen! Mitov highlights the importance of serendipitous discoveries, but cautions against pathological science. He raises several pertinent questions – how do we categorize soft matter? How do we tackle the structural complexity of these materials? Can faith and science coexist?

The book begins with a charming preface by Jean-Claude Carriere, the screenwriter of classic movies like *Diary of a Chambermaid* and *Belle de Jour*. It contains bonus tracks and references for further reading and concludes with two exhaustive lists of the casts of characters – separate alphabetical listings of all the sensitive materials we were introduced to in this book and the keen practitioners of the science of soft materials. The book is well-written, easy to understand and a lot of fun. It will appeal even to those who have just a fleeting interest in science.

RANJINI BANDYOPADHYAY

Soft Condensed Matter Group,
Raman Research Institute,
C. V. Raman Avenue,
Sadashivanagar,
Bangalore 560 080, India
e-mail: ranjini@rri.res.in