In this issue

Mimicking bone formation

Cell and tissue, shell and bone, leaf and flower, are so many portions of matter, and it is in obedience to the laws of physics that their particles have been moved, molded and conformed. . . . Their problems of form are in the first instance mathematical problems, their problems of growth are essentially physical problems, and the morphologist is, ipso facto, a student of physical science

—D'Arcy Thompson

G. P. Gladyshev (Semenov Institute of Chemical Physics, Moscow) in a paper entitled 'Thermodynamic direction of biological evolution: Model and reality', says: 'Understanding of evolution and behaviour of the natural systems is to a great extent based on classical natural science. Two approaches have played a special role: thermodynamic and kinetic. Thermodynamic description of the systems and phenomena is based on the concept of equilibrium. . . . Non-equilibrium thermodynamics united both the approaches mentioned. However the results obtained so far are applicable only to certain phenomena. Something similar can also be said about the thermodynamic systems remote from equilibrium. They are both based on pure kinetic methods.'

Gladyshev developed a new discipline referred to as hierarchic thermodynamics or macrothermodynamics, which allows a study of living objects on the basis of equilibrium thermodynamics and physical chemistry of the natural systems. According to him: 'Macrothermodynamics is based on the principles of macrokinetics. In a sense, it is an alternative to thermodynamics of the systems close to equilibrium. Macrothermodynamic models can be used for studying weakly non-equilibrium processes of morphogenesis, which are analogs of phase transitions'.

It became possible to apply the models of macrothermodynamics to evolution of the chemical composition of living objects on the basis of quantitative data and present evidence for correspondence between the model and reality, especially in the case of a physicochemical model of a particular case of evolution of the living system: evolution of supramolecular structures (their chemical composition and structure). Some experimental results have confirmed the model applicability.

In the study of musculoskeletal system, integrated approaches include clinical studies of bone mineral acquisition during growth, experiments in skeletal functional adaptation and repair, and analytical models and analyses of bone growth, development, and adaptation.

In this context, A. Aksay Bhan (Princeton University) says: 'The length scales defining structure and organization determine the fundamental characteristics of a material. In biogenic materials, one observes a broad range of organizational length scales: (a) a hierarchical organization starting at the nanometer length scale, in which case, nanostructural design is the building block of larger scale composite structures; and (b) the nested levels of structural hierarchy that appear to yield improved properties for particular functions. . . . In biogenic systems, nanostructural design is accomplished through the self-assembly of organics. Inorganic structures form via template-assisted self-assembly, where self-assembled organic material (e.g. proteins and/or lipids) form the structural scaffolding for the deposition of inorganic material. Organic materials are organized on length scales of 1–100 nm and used as frameworks for specifically oriented and shaped inorganic crystals (i.e. ceramics such as hydroxyapatite, $CaCO_3$, SiO_2, and Fe_3O_4).' Template-assisted-nanostructuring (of ceramic thin films) which holds great promise as a synthetic scheme to produce nanostructured materials with novel thermal, electronic, optical, mechanical, and selective molecular transport properties and nanoscale-patterning with block copolymers have been studied. 'Similar to the processes observed in the processing of biogenic composites, the architectures generated through self-assembly of surfactants or macromolecules can serve as templates to process ceramics with nanostructural patterns. The two examples (given above) illustrate the potential of this approach.'

Bones are best adapted to their functional demands by their shape and material structure. From the mechanical point of view, they present optimized lightweight structures with best usage of material. Based on a continuum mechanical description and simple laws of evolution, numerical simulation techniques are developed to study the stress adaptive growth of bones.

Hota *et al*. (**page 1406**) deal with the growth of $CaCO_3$ precipitates into chains of length more than 300 microns using non-equilibrium systems of myelin in AOT/water. The authors report an intriguing use of myelin, a component of the insulating sheath which coats the axon in nerve cells and also draw a parallel to aspects of embryonic bone growth.

K. R. Rao

The Gilbert Hill

68.5, 65, 64 . . . 60 Ma – thus the debate goes on. Whether it is K/Ar, $^{40}Ar/^{39}Ar$ or $^{187}Re/^{187}Os$ method of dating, the age centres around the above numbers! Early alkaline volcanism started as early as 68.5 Ma, while the youngest age reported, based on laser heating $^{40}Ar–^{39}Ar$ technique on biotite in alkaline rock, is 60 Ma. The paper by Sheth *et al*. (**page 1437**) comes out with a similar lower age for the spectacular columnar basalt in Bombay (Mumbai). This spectacular structure is considered till now as a national geological monument. With the work of Sheth *et al*. it has gained international significance.

Such diversity in ages – are they related to laboratory inter-calibration, age of neutron-fluence monitors used to calibrate the ages or systematic errors that were not reflected in the formal analytical error estimate? If one argues that such problems are well taken care of, then these numbers indicate that regional differences of active periods of volcanism in different areas seem to exist in the Deccan Volcanic Province. From less than a million years, now the entire volcanic activity, with this finding seems to have taken place over a period of 9 Ma.

As new and high-quality data flow in, our knowledge on the age and duration of the volcanism is also widening. Every worker claims superiority over the others and discards the earlier figures! One thing is certain – the present age shows that our understanding of this world's largest flood basalt province is incomplete and more work needs to be done. The truth is eluding. The present debate is on what is presently exposed on the surface and no one knows the age of the flows buried below this thick pile along the west coast and Narmada. Until this is resolved, discussion on the age and duration of the Deccan volcanism is incomplete and the debate will continue!

D. Chandrasekharam