In this issue

Microgravity materials science and initiative on microgravity research in India

The progress achieved by the Indian Space Research Organization (ISRO) in the satellite and launch vehicle technologies have been reported from time-to-time in *Current Science*. State-of-the-art communication- and other satellites are designed and developed indigenously and some of these are launched into geostationary orbits using our own launch vehicles. In its future activities ISRO envisages lunar landing, planetary exploration and microgravity science.

In the special section on 'Microgravity Materials Science', S. C. Chakravarty and S. Chandrasekharan (**page 324**) trace the beginnings of Indian interest in this field to an international workshop held in September 1979 under the chairmanship of S. Ramaseshan. It was only much later, in 1997, that a national workshop on 'Materials Processing in Space and Space Biotechnology' was held at Bangalore to initiate a microgravity research program on a national level. Since then, three working groups dealing with (a) materials processing in space, (b) fluid physics dynamics, and (c) space biology and biotechnology have been involved in making concrete proposals for research initiatives.

The first efforts in microgravity experiments by Indian scientists were by the DMRL group in 1984 as a part of the Indo-Soviet collaboration. The article by P. Ramachandrarao (**page 326**) discusses the details of this experiment. 'The aim of the experiment was to evaluate the extent of undercooling in space and compare the same with terrestrial results to estimate the effect of convection on the nucleation behaviour', and the material under study was a silver–germanium alloy.

K. Chattopadhyay (**page 328**) gives a broad review of the different facilities that are used for microgravity materials processing experiments, covering a gamut of them, including drop tubes, space shuttles and platforms and, as the author points out, 'surprisingly in recent time, balloons'. This article also makes contact with other articles in this special section at various places. After dealing with the program of 'Measurement of thermophysical properties', the author deals with scientific issues involving materials science microgravity experiments that are being pursued internationally. S. N. Ojha (see Box 1, **page 332**) deals with the process of microstructure development during solidification when, in addition to solute segregation, cellular or dendritic morphology could result. The macro segregation results by what is referred to as thermosolutal convection. Ojha suggests microgravity experiments to overcome this problem. B. K. Dhindaw draws attention (see Box 2, **page 333**) to the production of polyurethane foam which has as much as 50% less void size under low gravity conditions and also the ongoing trials of NASA to produce an almost weightless, strong, transparent and amazingly insulating solid referred to as 'frozen smoke' out of a substance called aerogel; it is said that it is easier to produce this under weightless conditions.

A. Tiwari's article (**page 334**) on liquid phase sintering deals with the role of gravity, rather, on the lack of it, on microstructure evolution in the liquid phase sintering process which is resorted to accelerate consolidation and sintering in the field of powder metallurgy. Studies conducted over the past two decades in low gravity and microgravity conditions, have helped in understanding the behaviour of liquid phase sintering but at the same time thrown up anomalous results. Better understanding of various kinetic and structural aspects of liquid phase sintering can be obtained only with more experiments.

ISRO's plan for microgravity research is along two directions; (a) to make use of stratospheric balloon-drop tests in the immediate future, and (b) to develop a recoverable and reusable satellite as a long-term option. V. A. Thomas *et al.* (**page 336**) review various platforms that are currently providing microgravity environment in the international arena: drop towers, parabolic flights, balloon drops, sounding rockets, recoverable satellites, space shuttles, international space station and the like. The paper refers to the studies conducted at ISRO to develop a Microgravity Application Recoverable Satellite (MARS) and provides the specifications of such a satellite. India has had good experience in launching balloons and has set up all infrastructure facilities for this since the days of H. J. Bhabha. It is but natural that this National Balloon Facility at Hyderabad comes out to be handy and economical for conducting microgravity experiments in the immediate future, provided certain updating is taken care of.

B. K. Dhindaw (**page 341**) reviews the nature of research being pursued at NASA and ESA in various science disciplines under microgravity conditions: these include biotechnology, combustion science, fluid physics and materials science. The article goes into details of approved ongoing NASA and ESA activities in materials science. Thereafter Dhindaw deals with a research programme (as an experimental case study) with which he has been involved as a collaborator. 'The objective of this section is to show the evolution of space lab experiments, from identification of the problem to its successful execution in space.'

T. Asokan (**page 348**) deals with a topic which is somewhat different from other articles appearing in the special section. As he points out, 'there are two categories of space R&D efforts – (a) processing of materials *for* space applications, and (b) processing of materials *in* space'. In this context, this article deals with an overview of ceramic dielectrics *for* space-related applications and the problems associated with their poor performance in space environment. The dielectric breakdown in space can be minimized by reducing the concentration of surface defects; however, 'such investigations have to be extended to microgravity environment'.

K. R. Rao

Courtship and nesting behaviour of the frog, *Rhacophorus malabaricus*

'. . . to speak of music, when applied to the discordant and overwhelming sounds emitted by male bull-frogs and some other species, seems, according to our taste, a singularly inappropriate expression.'

—Darwin, *The Descent of Man in Relation to Sex*, 1871

Although frogs and toads (collectively known as anurans) do not always present themselves as attractive beings to most people, including apparently Charles Darwin himself, over the last two decades, this otherwise fascinating group of animals has emerged as a promising group of organisms in which to study the evolution of sexual behaviour. Anurans are ideal for such studies since the sexes among most anurans are often behaviourally different from each other, they are easy to mark and identify in the wild, marked individuals can be conveniently observed, and, unlike birds, mammals or insects, their eggs are fertilized externally. This makes it very easy in the field to assign maternal and paternal identity to the clutch with accuracy, and thus directly measure reproductive success of both the sexes.

Biology has often been called the science of diversity. And nowhere is this more spectacularly displayed as in the mating systems of many frogs and toads. The usual pattern, nevertheless, is for males to gather at a water body – small or large, temporary or permanent, still or flowing – where they establish resource-rich calling territories and attract females. A number of calling males of different sizes may aggregate at these sites, their calls varying in frequency, loudness, or even sequence patterns. Females visit these calling sites and choose certain males – either on the basis of their calls or size – for mating. Mating is achieved through the act of amplexus in which the male climbs onto the back of the female and clasps her firmly. Eggs are usually laid either inside the water or on the overhanging vegetation, and externally fertilized by sperm directly released by the male after they have been laid.

About 90% of anurans do not show any form of parental care and the eggs are simply left unattended by both parents. Parental care of some kind is seen almost exclusively in terrestrial breeders. Terrestrial breeding is believed to have arisen due to an unpredictable aquatic environment, especially in the tropics. Considering that the tropics are extremely species-rich, it is also conceivable that there must be intense competition for breeding space in these environments. This may have also forced certain species to move out of water, and a subsequent need to provide an ‘aquatic’ environment on land. Not much, however, seems to be known about the kind of adaptations that may have arisen in the nature of sexual reproduction and parental care in species that have made this transition, particularly in India. On **page 377** of this issue, Kadadevaru and Kanamadi describe the courtship and nesting behaviour of *Rhacophorus malabaricus*, a rhacophorid frog endemic to the Western Ghats, and focus attention on some of the adaptations displayed by this species, which enable it to breed out of water.

Many tree frogs that nest terrestrially embed their eggs in foam nests. *R. malabaricus* males produce the foam by whipping up the seminal fluid after the eggs had been fertilized. The females of this species then complete the construction of an elaborate nest by pulling leaves close to the one on which the eggs have been laid and binding them to the foam to enclose the eggs from all sides. Leaf-covered foam nests of this kind may not only serve to protect eggs laid on land from desiccation, but perhaps also from some predators as well. A remarkable adaptation adopted by an aquatic species to breed on land – an otherwise hostile environment for its delicate eggs.

The Western Ghats is noted for its abundance of amphibians and reptiles, most of which are endemic to the region. For many of these taxa, the distribution patterns, species boundaries and the underlying population genetics remain completely unexplored. What is even more amazing is that new species are being discovered even today and many more still await discovery. One noteworthy example, is *R. pseudomalabaricus*, recently discovered and described from the Anamalais mountains of the southern Western Ghats by Vasudevan and Dutta (*Hamadryad*, 2000, **25**, 21–28). Although striking in its resemblance to *R. malabaricus* described here, the new species is believed to be somewhat different in its morphology and development. What Kadadevaru and Kanamadi’s description now brings to light is a remarkable behavioural difference between the two species. While *R. malabaricus* females invariably squeeze the back of the male during copulation apparently to facilitate sperm release, *R. pseudomalabaricus* males do not seem to need such coaxing. Moreover, the foam nest of the former species is made by the males with the females adding on the glued leaves; in the latter species, it is the female that whips up the foam and also incorporates the leaves. With more studies, this should become a wonderful example of an often-neglected fact – of how a description of small behavioural details can often trigger off a major understanding of the taxonomic status, ecology and evolution of two very closely related species.

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