In this issue

Chemotherapy for Indian kala-azar

Kala-azar or visceral leishmaniasis (VL) is a disease that was described in India, and antimonials as its cure was discovered by an Indian, U. N. Brahmachari, in the early 20th century. Nearly 90% of VL cases are now reported from Bangladesh, Brazil, India and Sudan. At least 5000 deaths occur in India annually. Leishmania/HIV co-infection is also an emerging threat in southern Europe among AIDS patients. Occurrence of the disease was rare in the 1950s and 1960s, but resurgence started since 1974. Out of all the kala-azar cases in India, 90% occurred in north Bihar during 1987–1998. The disease is to be eradicated by 2010 in India.

The parasite, a trypanosomatid protozoan *Leishmania donovani*, goes through two morphogenetically distinct stages during its life cycle. Amastigote (aflagellate) or leishmania stage is found in man inside the macrophage cells. The promastigote (flagellate) or leptomonad stage is found in vectors as well as in cell cultures.

Treatment in the 20th century depended on chemotherapy and improving personal hygiene and living conditions. Three available anti-leishmania drugs are sodium stibagluconate, pentamidine and amphotericin B. These are administered by injection or infusion. At times they develop toxic side-effects. About 40% of cases in Bihar are becoming insensitive to antimonials. Vaccines for leishmaniasis are under various stages of investigation. An oral drug, Miltefosine, has recently been registered for use, which is likely to 'revolutionize' the treatment of VL.

Neeloo Singh (**page 210**) describes an *in vitro* assay system to study effectiveness of sodium antimony gluconate (SAG) as a therapeutic for VL. The use of hamsters as animal model for testing drug resistance has already been published. The author used an *in vitro* culture of amastigotes in macrophages to investigate the drug resistance mechanism of *L. donovani*. The resistant strains isolated from Varanasi, Uttar Pradesh and Muzaffarpur, Bihar would be useful for Indian researchers.

S. G.

Thalassaemia

Thalassaemia (US, thalassemia); Greek thalassa (sea) + -aemia (*Concise Oxford Dictionary*), hereditary anaemia first found among children living around the Mediterranean Sea.

The commonest hereditary disorder among the Indian population is β-thalassaemia major (TM), or simply thalassaemia. About 8000 thalassaemic babies are born in India every year. The defective gene is an autosomal recessive, meaning that the heterozygous carriers are symptomless. The homozygous children usually die of cardiac failure in early childhood. While frequent transfusion could be used to relieve the symptoms, the only definite cure for the disease is bone-marrow transplantation. Annual cost of treatment of a thalassaemic child would be up to one lakh of rupees.

Saxena and Phadke (**page 291**) conducted a survey among 100 couples with a thalassaemic child to analyse their pedigree. Despite the conservative attitude to protect familial privacy, the authors found that, by and large, parents share information about their children. Counselling about genetic risks appears to be the only available way to contain the disease.

S. G.

Effects of fire

Paliwal and Sunderavalli (**page 316**) describe an approach in assessing the damage caused by a fire in grazingland ecosystem. The study was conducted at Madurai, Tamil Nadu during July 1993 to June 1994. About 0.2 ha area was intentionally burned and compared to an adjacent plot of 0.25 ha that was left unburned. Biochemical and biophysical methods analysed the nutrient contents from these grasslands after the experimental burning. The study concluded that major plant nutrients, except K, were higher in the unburned control, and that burning stimulated cycling of nutrients.

S. G.

Immunity in silkworm

Immunity to 'non-self' invasive pathogens in mammals is mediated by complex and elaborate mechanisms of self-defence. Silkworm (*Bombyx mori*), a simpler organism, utilizes a burst of superoxide anion in the haemolymph to neutralize the bacterial pathogen, a phenomenon similar to what is found in polymorphonuclear leucocytes in mammals. Krishnan *et al.* (**page 321**) measured the superoxide dismutase activity in the haemocytes and in the plasma of fifth instar larvae of silkworm following infection of *Bacillus subtilis*. This work confirms the parallels drawn between higher animals and insects as regards immunity to bacterial infection.

S. Ganguli

Plasma technology

Many social thinkers and writers such as Alvin Toeffler, Peter Drucker, James Brian Quinn and John Handy have been heralding the emergence of a new economy based on information and knowledge creation. The dotcom companies are not the only symbols of this economy. The nature of manufacturing technologies has been steadily changing over time through the increasingly active and assertive role of knowledge as a production factor. Enabling this sanskritization of manufacturing is a host of new technologies. The empowerment of manufacturing by knowledge has already taken place by the invasion of the factory by microprocessor and information technology. The tools of transformation to the post-industrial manufacturing are all characterized by one common feature; they are all minimalistic in concept and execution. Synthesis is almost on an atomic scale and functional to the core.

Plasma-assisted manufacturing (PAM) is one such technology which exploits plasma as an industrial tool. Plasmas are ionized gases with free electrons, ions and excited neutrals. The charged particles can respond to external electromagnetic energy fields and transport energy. The fluid properties are enhanced by the particles setting up internal self-consistent electric and magnetic fields, resulting in collective effects like flows, waves, instabilities and self-organization. Each species may have independent energy distribution, not necessarily in equilibrium with other species. The internal energy is composed of thermal, electric, magnetic and radiation fields, whose relative magnitudes allow the plasma state to exist in an extended, multi-dimensional parameter space.

When materials are exposed to plasmas, a variety of physical, chemical and metallurgical transformations of the material take place. PAM integrates the plasma–material interaction phenomenon with the manufacturing process. The PAM technology adds value to conventional materials and makes new types of materials and material-processing techniques possible.

Plasma-aided manufacturing is forecast to have a direct impact on the world economy in virtually every aspect of industry[1]. It has an astonishingly wide range of applicability. A recent US National Research Council report[2] indicates a number of important uses of plasmas which include hardening of tools, pasteurization of foods, decorative laminations, sterilization of medical products, environmental clean-up, gas discharges for lighting and lasers, high-definition television, isotope separation, switching and welding technology, and plasma-based space propulsion systems.

The major impetus for the growth of plasma sciences came from the search for conditions in which fusion of deuterium and tritium nuclei to form helium would yield nuclear energy. Similar nuclear reactions make the stars burn and give the hydrogen bomb its awesome destructive power. To release this energy in a controlled manner on the earth requires many conditions to be simultaneously fulfilled. The plasma must have a temperature of hundred million degrees to overcome the natural tendency of the nuclei to repel each other, for them to come close enough for nuclear forces to take over and fuse them. It must be confined long enough for fusion reactions to release more energy than was expended to heat it; the Lawson criterion which requires the product of density and confinement time to exceed 10^{14} s per cubic centimetre. The plasmas should also be insulated from the surroundings so that they do not lose heat or get contaminated by other materials, which can affect the fusion yield.

Fusion research started in the 1950s. The approaches to achieving fusion conditions have taken two directions. In one, called inertial fusion, intense pulses of laser energy irradiate minute solid pellets of fuel. The outermost layer absorbs the laser energy and ablates outwards. The resulting inward reaction on the rest of the pellet produces inward compression and heating. The compression of the pellet and the fusion burn would take place for less than a microsecond. The National Ignition Facility being built in the US will use 192 laser beams, applying 1.8 MJ of energy to prove this concept.

The other approach is to trap low-density plasmas in magnetic traps and heat them using a variety of energy sources like large currents, intense radio-frequency fields or energetic neutral beams. The most successful of such traps is the tokamak, invented by Russian scientists, Igor Tamm and Andrei Sakharov. Tokamak has a tyre-shaped vacuum vessel, which is filled with a low-pressure mixture of deuterium and tritium. A magnetic coil wound around the chamber produces a toroidal magnetic field. The current flowing in the toroidal plasma heats the plasma by ohmic dissipation and also produces a poloidal magnetic field, which, in conjunction with the external toroidal magnetic field, produces confining magnetic surfaces to which the plasma particles stick.

Fusion energy is still a distant hope. Part of the problem is the mastery of a number of difficult technologies. The hot plasma can be confined only by magnetic fields of specific and very often, complex topologies. The heat insulation of the magnetically confined plasma is imperfect and even now incompletely understood. To heat the plasmas, currents of the order of millions of amperes have to be induced inside the plasma, and further irradiated by intense electromagnetic fields and particle beams with power density in the range of megawatts/sq. metre. The hot, magnetized, current-carrying plasma exists in a delicate equilibrium and develops instabilities at the slightest provocation, dumping mega joules of energy in milliseconds into the walls and magnetic field coils. The helium ash and the impurities generated by the interaction of the plasma with the confining walls will have to be exhausted before they can poison the plasma and cool it by radiation. The fusion core has to be coupled with the neutronics to tap the neutron energy through conventional thermal cycle. These formidable problems, as well as issues like the grid impact of large fusion systems, radioactivity in the first generation deuterium–tritium fusion reactors, reliability of technology and the economic viability have generated as many detractors to fusion as there have been champions. The promise of fusion is on the verge of fulfillment, and laboratory devices have shown that fusion is feasible in the laboratory. Experiments such as the Joint European Torus at Culham, UK and the Tokamak Fusion Test Reactor at Princeton, USA have demonstrated its scientific feasibility through experiments in which fusile deuterium–tritium plasmas were burned to produce thermonuclear neutrons, albeit at power levels of the order of a few megawatts. The next step towards the goal of power-producing reactors is the International Tokamak Experimental Reactor (ITER).

Fusion research, however, was the prime driver for the development of a host of technologies for producing and manipulating plasmas of an extended parameter space and understanding their interaction with matter and fields. This has led to the large-scale nucleation and growth of the industrial technology of plasma-assisted material processing. Rapid growth of this field started in the seventies, when it became an enabling technology for semiconductor device fabrication. Parallel developments in applications also took place in modification and engineering of surfaces with plasmas, synthesis of advanced materials in thermal plasmas, development of advanced coatings and films, etc.

The growing perception of the strategic importance of PAM is reflected in intensification of efforts in structuring research linkages with industries. The declining fortunes of fusion also helped this indirectly, as a large number of plasma scientists began to look for new research opportunities in application areas. Parallel to what happened in fusion research, there is a growing realization that strengthening the science base was important to break the technology limits. Powerful experimental, diagnostic and computational tools originally developed for fusion became increasingly adapted to research in plasma-assisted material processing.

The special section in this issue of *Current Science* highlights the versatility of plasma as an enabling tool for industrial, manufacturing and engineering applications.

1. National Research Council, *Plasma Processing of Materials: Scientific Opportunities and Technological Challenges,* National Academy Press, Washington, DC, 1991.
2. National Research Council, 'Plasmas and Fluids', in the series *Physics Through the 1990s*, National Academy Press, Washington, DC, 1986.

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