In this issue

A great chemist

One hundred and twenty five years ago, an unknown chemist in Russia, while trying to give a course of lectures to university students, felt the need for a good textbook in general and inorganic chemistry; so he wrote one. His name was Dimitry Ivanovich Mendeleev. Into this book he put in a favourite idea of his on which he had mulled over for years. This became one of the greatest generalizations of chemistry and it elevated Mendeleev to the status of one of the most outstanding chemists—almost equalling that of Lavoisier and Dalton.

The famous chemical congress of Karlsruhe, which made history, was held in 1860. Here the distinction between atoms and molecules was first thrashed out and there were also detailed discussions on atomic weights and how they were to be determined. Mendeleev attended this conference along with his friend A. P. Borodin the great composer, who was also a chemist. It was here that he conceived of the idea that the property that made atoms different (or alike) depended on their atomic weights.

And for eight years he passionately contemplated the elements. Great strides are often made by individuals pondering over a single problem, playing intellectual games which slowly reveal to them the inner organization of nature. Mendeleev wrote the names of each element along with its atomic weight on cards. He had 63 cards which he shuffled and with them he played the game of *patience*, arranging them in all sorts of manner, into rows and columns, horizontally, vertically and diagonally, searching all the time for a systematic sequence. He at last found a recurring pattern when atoms are arranged in the order of their atomic weights. When he arranged them using his newly discovered key, he perceived that there were gaps. With inspired intuition he interpreted these gaps as unknown elements yet to be discovered. He was right, for many of these elements were indeed discovered even during his lifetime. Half a century later Mendeleev's periodic table served as a critical check on the theory of atomic structure which was devised by Niels Bohr.

It is not too well known that Mendeleev in 1859 also had made an important discovery—in physical chemistry—that for every substance there exists a temperature above which it cannot be condensed from a gaseous state to the liquid state. His discovery of the *critical point* was long neglected till it was rediscovered by Andrews.

Mendeleev's life reads like a Russian novel—seventeenth and last child of a comparatively poor family in Siberia, with a heroic mother who ran a glass factory to support her children. When fire destroyed the factory, she with great determination moved to Moscow and St. Petersburg mainly to educate her brilliant son. It was a pity that this remarkable woman did not live to see her son's great achievements. Mendeleev contracted tuberculosis at the age of 22 and his doctors gave him only a few years to live. They were wrong as he died at the age of 73 (1907). His first marriage was very unhappy and it ended in a divorce. His second, when he was 45, was to a beautiful seventeen-year-old girl and was very happy. But the Greek Orthodox Church would not recognize divorce and so he was considered a bigamist. The Czar would not dismiss him saying, 'Yes Mendeleev has two wives but I have only one Mendeleev!'

As he grew old, he became more and more unconventional and absent minded. He developed all the idiosyncracies that most men of genius are wont to develop, including insisting on the correctness of some of his later theories even if the evidence showed them to be incorrect. He always appeared with an enormous head of hair, which he cut only once a year. He would not deviate from this custom even when he had to have an audience with the Czar.

Since then much research has been done to improve the periodic table (see *Graphic Representation of the Periodic Table Over a Hundred Years* 1970) by E. G. Mazur, University of Alabama). Attempts have been made to include into it many parameters like atomic radius, polarization, ionization potential, electronegativity, etc. G. S. Ranganath (page 449) discusses a recent three-dimensional form of the table (which incorporates into it Hund's rules) which seems more satisfactory than most.

Meghnad Saha

This is the centennial year of the birth of our outstanding physicist M. N. Saha. On **page 530** Virendra Singh writes a perceptive article about Saha. Unlike his contemporary (and classmate) S. N. Bose who oozed charm, Saha 'gave an impression of being remote, matter of fact and even harsh, but once the outer shell was broken, one found him to be a person of extreme warmth'. We met him in late 1955. There was no doubt that he was a greatly troubled man, very cynical about Indian science and India's progress as a nation. We reproduce a paragraph, written by D. S. Kothari, which epitomizes the scientist and the man.

The name of Professor Meghnad Saha would always remain associated with the theory of thermal ionization and its application to the interpretation of stellar spectra in terms of the physical conditions prevailing in the stellar atmospheres. The theory had all the simplicity and inevitableness which usually characterize a fundamental and epochal contribution. It was almost a direct consequence of the recognition that the laws of thermodynamics and the kinetic theory of gases can be extended to a gas of free electrons. Apart from astrophysics, the theory later found numerous other important applications, such as, to mention some of them, in the study of the ionosphere, conductivity of flames, electric arcs and explosion phenomena. Saha's researches in astrophysics and physics extended over a wide range of subjects. At one time or the other he worked on stellar spectra, thermal ionization, selective radiation pressure, spectroscopy, molecular dissociation, propagation of radio waves in the ionosphere, solar corona, radio emission from the sun, beta radioactivity, and the age of the rocks. Besides physics, he took a keen interest, at times, almost bordering on the professional, in ancient history and archaeology. He was a devoted and inspiring teacher, and he gave his time generously to his students. He organized active schools of research at Allahabad and Calcutta; and in establishing the Institute of Nuclear Physics at Calcutta, in building the laboratories of the Indian Association for the Cultivation of Science; and in founding academies of sciences in India, his role throughout was of the utmost importance. He, more than anyone else, was responsible in starting the monthly journal *Science and Culture*, and he was its editor for many years. He was from the beginning a member of the Council of Scientific and Industrial Research constituted by the Indian Government in 1942, and member (or chairman) of several of the research and other committees of the Council. He was the Chairman of the Council's Indian Calendar Reform Committee. He was an elected independent member of the Indian Parliament. He took the keenest interest in problems of national planning, particularly in relation to science and industry. He was an active member of the National Planning Committee appointed by the Indian National Congress in 1938 with Jawaharlal Nehru as chairman. In his criticism of things and men, Saha was fearless and trenchant, and he was motivated by a deep earnestness and sincerely, though often tenaciously, held convictions. His memory and versatility were amazing. He was extremely simple, almost austere, in his habits and personal needs. Outwardly, he sometimes gave the impression of being remote, matter of fact, and even harsh, but once the outer shell was broken, one invariably found in him a person of extreme warmth, deep humanity, sympathy and understanding; and though almost altogether unmindful of his own personal comforts, he was extremely solicitous in the case of others. It was not in his nature to placate others. He was a man of undaunted spirit, resolute determination, untiring energy and dedication. On 16 February 1956, on his way to the Office of the Planning Commission in New Delhi, he succumbed to a sudden heart-attack (some hundred yards from the Office of the Commission) and at the age of sixty-two, a career superb in science and great in its promotion and dissemination was tragically closed.

D. S. Kothari (1906–1983)

Published on **page 528** is the obituary of D. S. Kothari — one whose knowledge of physics was unmatched and one who was perhaps amongst the greatest teachers of physics the country has had, and one who created a most impressive school of theoretical physics in India. His simplicity and humility were bye words. He was truly great in that his values and ideals were unshakeable. Many instances can be quoted. Here is one.

I wrote to him in 1985 that the academic community, to which he had rendered so much service, is keen on bringing out a felicitation volume to celebrate his 80th birthday. 'It would be most appropriate because of the original contribution you have made to research and, also because of your dedicated services as a teacher in spreading physics at all levels.' Kothari was very much against this idea and wrote in his own hand a delightfully courteous letter. 'I am touched by your letter and I cannot express adequately my feelings. But I would sincerely request you and your associates not to pursue this matter. The proposal (of bringing out a felicitation volume) *must kindly* be dropped. Let me say again how much I value your letter.' In spite of a large number of persuasive letters from physicists, many of his students and admirers, he was quite adamant in his refusal. His main stand was that individuals should never be singled out in this manner. This helps the growth of a personality cult which in the long run is very harmful to the growth and temper of science in the country. What is worse, it leaves in oblivion many who make important contributions in their own silent way. Yes, he was a truly remarkable human being.

Generalization about specialization: from cells to societies

The greatest of pursuits in science have been for universally valid laws of Nature. While spectacular successes have been obtained in relatively simple areas of sciences like physics, in the complex disciplines like biology, general principles are (perhaps of necessity) few and far between. The key here is to ask the right questions. In his Gandhi Memorial lecture, reproduced on **page 459**, J. T. Bonner gives an elegant illustration of a general principle about the patterns and causes of the diversity of functions which emerge when individual units (ranging from amoebae to humans) group together to form aggregates of varying sizes.

Probably the simplest of the multicellular organisms is the slime mould, which spends part of its life cycle as a solitary amoeba, and part as member of a collection of amoebae which together form a slug. Even at such a primitive level of organization there is specialization (division of labour) — some cells form spores which eventually produce the next generation of cells, while others form merely a supporting stalk. Tracing the increase in complexity from slime moulds to plants, to invertebrate through to vertebrates, Bonner shows how an increase in the number of cells leads to an increase in the number of cell types; more the number of cells, more are the different kinds of them, performing different functions. Both physics and biology have been brought in to explain this pattern. The volume (and hence the total mass) grows as the cube of the linear dimension, while the surface only as a square. Consequently, for large collections of cells, the surface to volume ratio is smaller, and more specialized cells are needed for the transport of oxygen, nutrients and toxic wastes between inside and outside. More specialized the cells, more efficient is the transport, and the inexorable process of Natural Selection then lets only the most efficient (fittest), i.e. those with more specializations, survive. It is this principle which holds good even at the next higher level of organization, colonies of social insects-bees, wasps, ants. Here, too, emergence of more 'castes' (different individuals specializing in care of the young, foraging, fighting, egg-laying) makes the colony more efficient, and natural selection favours more efficient colonies.

In human societies, increasing numbers lead to more specialized economic activities and a more pronounced division of labour; larger societies show a higher number occupations. Such an increase in diversity accompanies an increase in size of other human institutions as well, be they business conglomerates or university departments. The origins of diversity in human societies, however, are behavioural (and not genetic, as in the case of cells and insects). The human mind, with its highly evolved problem solving ability, is able to create a tremendous diversity of behaviours. These patterns of behaviour (called memes) are transmitted far more rapidly and efficiently than the genes. Larger human societies therefore have a much higher diversity of behaviours which can (and unfortunately invariably does) lead to conflicts. The two most important problems faced by mankind today (population explosion and social instability) are thus presented from a very novel evolutionary perspective — success of genes and success of memes. While admittedly falling far short of offering solutions, such insights nevertheless lead to a better understanding of the problems, which is a prerequisite for obtaining satisfactory solutions.