Creativity in science and music

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'A pre-requisite for creativity is that we must cease to take for granted that we are incapable of creativity!'

– Bohm and Peat[1]

Exhortations to be creative invariably form part of the advice extended by senior scientists to their junior colleagues. But what is creativity? What is the role of creativity in evolution? I looked through the writings of some famous scientists and original thinkers to see if I could find clear answers to such questions. Prigogine, for instance, is reported[2] to have drawn an analogy between the sudden emergence of revolutionary ideas in science, and what happens to systems under far-from-equilibrium conditions. Such occurrences are characterized as non-average behaviour. Jacques Monod comes out with an even more complicated version[3]: 'Thought is based on an underlying process of subjective simulation . . . . As the instrument of intuitive preconception continually enriched by lessons from its own subjective experiments, the simulator is the instrument of discovery and of creation.' Quite obviously this needs paraphrasing! The gist seems to be that in the course of evolution, the power of simulation developed in the central nervous system of early man. Natural selection tested the efficacy of this process, and its survival value. Our logical thinking is based on such simulation, and thinking ultimately leads to creativity. But creative thinking cannot be the result of logic alone; something more is required. Karl Popper, for instance, believes that imagination plays a vital role in the development of new theories[4]. The free roaming of thoughts is a key component of this process. The organic chemist, Berson too has expressed the same idea using a more classical metaphor[5]; the essential pre-condition of creativity is a blending of discipline and fantasy – the proper mixture of the classical and the romantic, 'the Apollonian and the Dionysian'.

Arthur Koestler, who claims to have developed a 'theory of human creativity', feels that discoveries in science do not create something out of nothing; they merely integrate pre-existing ideas and facts[6]. Obviously, this begs the question of how the ideas came into existence in the first instance. But Koestler does come close to the mark when he says that all coherent thinking is governed by 'rules of the game'. This has been further elaborated by Thomas Kuhn, David Bohm and Karl Popper. In the field of science, such 'rules of the game' constitute what Bohm refers to as the 'tacit infrastructure of ideas and concepts', and may correspond to Popper's 'World 3'. This tacit infrastructure refers to the prevailing body of theories and concepts which bear the stamp of approval from the science establishment. These theories, embedded in the subconscious mind of the practising scientist, make him or her resist any change to the existing way of thinking in a radical manner. This acts as a stumbling block to new, revolutionary concepts being put forth. The mind has a strong tendency to cling to what it finds familiar and to defend itself against anything, which threatens to upset the equilibrium.

But once in a while, there comes a genius, whose mind shows itself capable of rising above the shackles of the conventional, and reach out for something totally new. It is this, which leads to revolutionary breakthroughs in science.

Creativity, thus, has its task cut out: it has to overcome the embedded antagonism to new ideas or concepts.

Thomas Kuhn proposed that the history of development of science is marked by long periods of 'normal science' during which the fundamental concepts are not challenged. But these periods are interspersed with sudden paradigm shifts during which theories and ideas change radically and whole new systems of concepts are created. (Kuhn seems to have been the first to use the term 'paradigm shift'; a paradigm is not just a particular scientific theory, but a whole way of thinking and perceiving.) While radical changes do indeed take place during such a paradigm shift, quite significant advances may also take place during the 'normal science' phase. Creativity is not restricted to periods of revolution alone!

Let me elaborate this point. The remarkable achievements in organic chemistry during the 20th century can be traced to a few major developments during that period – the electronic theory of organic transformations, the principle of conservation of orbital symmetry, and conformational analysis. The scientists who were responsible for the advent of these theories were intellectual giants, some of them true geniuses: Pauling, Robinson, Ingold, Woodward, Hoffmann, Barton, Hassel and Prelog. The new theories they propounded were *advances* of extraordinary significance; but none represented a total break from the existing infrastructure of ideas. If one were to identify such a truly remarkable manifestation of creativity in organic chemistry which presaged a paradigm shift, one would have to go back to the 19th century when Couper, Butlerov, Kekule and van't Hoff introduced the structural theory and the tetrahedrally oriented quadrivalency of carbon[7]. To quote Woodward: 'The structure theory recognized that the maintenance of nearest-neighbour relationships among the elements was responsible for the variety and individuality of the material components of the physical world.'

The slow, long-term transformation during the 'normal science' phase, thus involves the operation of creativity on a continuous basis. It is in this context that one must assess the role of the average research scientist. It is commonly assumed that only a person of exceptional talent would be capable of a truly creative act and that the ordinary scientist, without any pretensions of being a genius, is shackled by the 'tacit infrastructures' of subliminally held ideas. This may not be true. Creativity is not incompatible with functioning within the ambit of the existing set of rules. There is enough evidence to believe that all human beings are endowed with the creative potential when they are born[1]; this can be seen in the behaviour of children. However, as children grow older, this creative urge fades, or is smothered under the weight of the tacit infrastructure of existing concepts. The mind is blocked from engaging in free play of thought that is absolutely essential for creativity. The effort must therefore be to liberate this thinking process from the grip of the rigid ideas, while retaining the specific artistic, mathematical or scientific form.

According to Bohm, the 'infrastructure of ideas' extends to art as well, and ultimately into society itself. But there seems to be a fundamental difference between the history of science and the history of art, especially of music. Is there something identifiable as 'progress' in music, comparable to 'progress' in science? Are there periods in the history of music when revolutionary changes have taken place, leading to radically new concepts or practices? I am aware of none, at least in Indian classical music. The system based on *swaras*, *ragas* and *talas* has been in existence since time immemorial – some say from the period of Vedic chants. To be sure, within this framework, there have been, from time to time, several novel innovations to the form and content of the music. One such outstanding development in Carnatic music took place during the late 18th and early 19th centuries when the three great composers, Tyagaraja, Muthuswami Dikshitar and Syama Sastri created a vibrant body of compositions, referred to as *kritis*. I am emboldened to say that Indian classical music has been on a continuous creative path, devoid of paradigm shifts.

In contrast, over the last hundred years or so, classical Western music has experimented with its basic format. It has moved from tonality to atonality and ultimately to electronic sound. The consequences for the listener, however, have not been uniformly pleasant! The contrast from the glorious music created by Bach, Handel, Beethoven or Schubert to any of the modern composers is too stark.

Several decades ago, as a young scientist, fresh from a post-doctoral sojourn abroad, and eager to find evidence of dynamism in Indian society, I was engaged for a brief period in a futile search for similar 'progress' in classical Carnatic music. But maturity has brought with it greater aesthetic appreciation; and, fortunately, the brain has still retained the memory of some outstanding musical experiences – the brilliance of Ariyakkudi's *neraval* in the *anupallavi* of Sri Subrahmanyaya Namaste, the haunting *Latangi alapana* of Mali which brought tears to the eyes of the whole audience, the grandeur of Voleti Venkateswarlu's *Kalyani alapana,* the poignancy of M.S. Subbulakshmi's *Kiravani,* and the peace and contentment which I experience every time I listen to K. V. Narayanaswamy's *Kapi*. I now know instinctively what creativity in Indian music means; but I cannot define it.

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2. Toffler, A., In his Foreword to Prigogine, I. and Stengers, I., *Order Out of Chaos*, Flamingo, London, 1985.
3. Monod, J., *Chance and Necessity*, Collins, Glasgow, 1971.
4. Popper, K. and Eccles, J. C., *The Self and its Brain*, Routledge, London, 1977.
5. Berson, J. A., *Tetrahedron*, 1992, **48**, 3.
6. Koestler, A., *Janus: a Summing Up*, Pan Books, London, 1978.
7. Woodward, R. B., Cope Lecture, In *Robert Burns Woodward: Architect and Artist in the World of Molecules* (eds Benfey, O. T. and Morris, P. J. T.), Chemical Heritage Foundation, Philadelphia, 2001.

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D.D.T.

Dichlor-Diphenyl-Trichlorethane (DDT) was originally synthesised by Othamar Zeidler in 1874 and its physiological and pharmacological properties remained unknown till this important chemical was rediscovered by Paul Muller of the USA. Department of Agriculture. But Frey of Cincinnati Chemical Works, USA, solved the problem of its production on a commercial scale. The Americans consider it one of the most important discoveries of World War II and truly this insecticide can be termed as such. Paul Muller found that it killed bugs and it was first tested in 1939 during the plague of potatoes where it killed all the beetles. In 1943 it was used in Naples where it stopped the epidemic of Typhus. The matter must have been of very considerable importance that the Prime Minister Churchill made a special mention of DDT in his latest review of war before the House of Commons. DDT promises to wipe out mosquito and malaria and to destroy household pests such as cockroaches and bedbugs, and to control some of the most damaging insects. Lt.-Col. Ahnfeldt, of US Surgeon-General's Office, considers that DDT will be to preventive medicine what Listers' discovery of antiseptics was to surgery.

The use of DDT as delousing agent against Typhus has been an open secret in America for several months. But in June last for the first time its manufacturers and Army, Agriculture and W.P.B. officials announced some of its amazing properties:—(1) If sprayed on a wall it kills any fly that touches the wall for as long as three months afterwards; (2) a bed sprayed with DDT remains deadly to bedbugs for 300 days; (3) clothing dusted with it is safe from lice for a month, even after eight laundrings; (4) a few ounces dropped in a swamp kills all mosquito larvae; (5) it is deadly to household pests such as moths, cockroaches, termites and dog's fleas; (6) as a crop protector, it is deadlier and longer lasting than other insecticides. It has been found effective against potato beetles, cabbage worms, Japanese beetles, fruit worms against which other insecticides have proved to be failures.

USA has a very big programme in hand for its production but all for the army. DDT owes its deadliness both as a contact and a stomach poison. It first paralyses hind legs of an insect and finally brings complete paralysis and death. It is remarkable that pure chemical has little effect. It is used in an oil solution or mixed with an inert powder. The usual dose is 1–5 per cent. DDT. It is non-toxic to human beings in the concentration which is used.

For the first time it was synthesised in the Government Industrial Laboratory at Hyderabad-Deccan, and a programme for producing it on a larger scale has been undertaken.