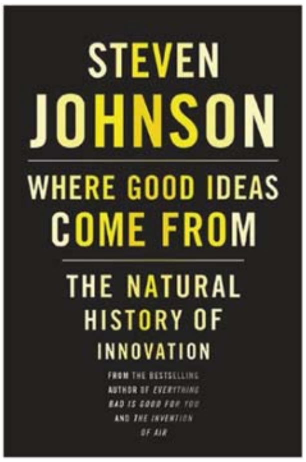

Where Good Ideas Come From: The Natural History of Innovation. Steven Johnson. Riverhead Books, New York, 2010. 313 pp. Price: US$ 26.95.

This is a book about the psychology and sociology of innovation and research. It is organized into seven chapters, apart from a separate introduction and conclusion section. Though the coverage of the book is broad, the topic discussed is important for researchers in science and engineering.

In the introduction, the author points out the importance of cities and the internet in fostering innovation. While living organisms tend to slow down as they become large, networked systems become more productive as they increase in size. For example, a city which is 10 times larger than its neighbour is 17 times more innovative. Here innovation was measured in terms of patents, R&D budgets, etc. This superlinear scaling is due in part to the abilities of cities to nurture subcultures of innovative people. The author compares this productivity of cities to the plethora of life seen in coral reefs which he uses as an example of a fertile ecosystem for biological innovation throughout the book. The World Wide Web offers similar advantages for networks. It provides access to information through search engines and promotes global subcultures of individuals who may be working in narrow and esoteric areas. Scientists will certainly appreciate how much easier it has become to take part as an author, reviewer and editor in the post-internet world.

Chapter 1 is entitled 'The adjacent possible'. The popular perception of research is that it comes from big breakthroughs. However, the reality is that most discoveries emanate from discoveries in the 'near field' of the known. The theory of the adjacent possible can also be used to explain the theory of 'multiples', which is the event where more than one researcher discovers a fact at about the same time, while working independently of each other. This fairly common phenomenon occurs because the accumulated knowledge-base obtained by other researchers reaches a point where a move into the adjacent possible by anyone will yield a new idea. The adjacent possible can also act as a constraint on ideas. For example, the discovery of oxygen required not only the knowledge that air is made of a variety of gases, but also advanced scales which could measure minute changes in weight caused by oxidation.

The second chapter is titled 'Liquid networks'. The power of networks comes not only from their numbers, but also from their interconnections with each other. The author mentions that innovative systems exist at the 'edge of chaos', which separates the orderly state (akin to solids) from the chaotic state (akin to gases). The liquid network thus facilitates existence at the edge of chaos where exploring of the adjacent possible is the easiest. The author mentions an interesting experiment where the laboratory environment of scientists was studied by sociologists by recording all the action taking place. The surprising finding was that most discoveries took place not at the microscopes or computers, but during discussions at the weekly laboratory meetings. The liquid network of the research group was instrumental for completing the thought of individual members and creating new ideas. It is inspiring to note that a network of thinking minds has considerable potential even in these days of big science and technology projects.

The third chapter is titled 'The slow hunch'. Large cities and the internet are dense liquid networks which provide the possibility of completing an idea which exists in a mind in a formative stage. The author calls this rudimentary idea a 'slow hunch'. According to him, 'most great ideas come into the world half baked, more hunch than revelation'. The hunch needs access to other minds to complete itself and hence the importance of the liquid network. The author details the hunches of Darwin and Newton revealed in their personal writings, which existed long before their ideas were published formally. The book reveals that during the early days of the enlightenment in Europe, scholars maintained a 'commonplace book', where they noted down various ideas which came to them and also took notes from their readings. This kind of notebook appears to be a good idea for researchers. The commonplace book should be periodically reread to see the evolution of past hunches. One suggestion in this chapter is to devote 20% of one's time for pursuing a 'pet project', totally guided by one's hunches.

The fourth chapter entitled 'Serendipity', which is the process of accidently discovering something which we are not in quest of. A striking example in this chapter is of a chemist who discovered the molecular structure of benzene while daydreaming about Ouroboros, a serpent from Greek mythology which devours its own tail. One way to enhance serendipity is through dream inspiration during which the 'dreaming brain stumbles across a valuable link that has escaped waking consciousness'. Sleeping over problems is a simple way to invoke dream inspiration. Other methods to increase the change of serendipitous encounters include going for a walk, eclectic reading, sabbaticals, etc. It seems to me that while the exploration of the adjacent possible reveals the 'known unknowns', serendipity can reveal the 'unknown unknowns'.

The fifth chapter is titled 'Error'. Here the author points out that many inventions involve a series of mistakes. According to the author, 'a shocking number of transformative ideas in the annals of science can be attributed to contaminated laboratory environments'. For example, penicillin was discovered by the accidental infiltration of the mould into a culture of *Staphylococcus* which was left near an open window of the laboratory. Errors create a path which deviates from the typically held assumptions, and being wrong forces one to explore. The author suggests that experiments which produce unexpected findings should be carefully studied for breakthrough ideas. He links errors to mutation in biology which can occasionally produce a good solution, but is generally undesirable. The capacity to tolerate mistakes and move forward is a hallmark of innovation.

The sixth chapter, 'Exaptation', describes a trait developed for a specific purpose that ends up being used for a completely different and unintended function. For example, bird feathers were originally meant for warmth and were completely symmetrical. However, asymmetry helps in high-speed flight and birds such as hawks have more pronounced asymmetry in their feathers. Thus 'a feather adapted for warmth was exapted for flight'. In another example, the author mentions how Gutenberg was able to invent the printing press because of his prior knowledge of the wine presses which he then exapted for printing. Exaptation benefits from 'weak ties' or elements of our network which are in the periphery. Since most networks are clustered, individuals who try to bridge these networks can create novel ideas. Among other things, exaptation may be nurtured by 'long, rambling coffee breaks' and by trying to do several problems at the same time.

The seventh chapter entitled 'Platforms' which are natural ecosystems that foster innovation. For example, beavers build dams to protect themselves from predators. However, a more important side effect is that the dam provides an ecosystem for many insects, birds and other creatures to flourish. According to the author, 'platforms create an entire new floor into the adjacent possible'. Various public sector-funded projects have created platforms for inventions like the GPS, internet, etc.

Finally, the author concludes the book with a section entitled 'Fourth quadrant'. He mentions four combinations under which innovation takes place. These are: (1) market/individual, (2) market/network, (3) non-market/individual and (4) non-market/network. He points out that most inventions in the modern world come from the non-market/network quadrant, which is the fourth quadrant. A research university is the main example of such a fourth quadrant institution. However, the presence of a critical mass of people and organizations in both the market and non-market domains is needed to get the full economic value of a scientific idea.

Overall, this book provides a lot of valuable ideas, examples and case studies for researchers in science and technology. The book makes extensive use of analogies from biology and computer science to illustrate the ideas. Various biographical details of individuals and organizations that used the different methods to create new ideas are provided. I found the discussions on the research methods of individual scientists particularly interesting. However, the book does not give importance to teaching, which can be done in a manner so as to activate many of the ideas presented. Generally, research is learnt by most people from a practitioner, but even accomplished researchers may not be using the full array of the possibilities presented in this book. The book will certainly help researchers who want to learn more about the art of innovative research.

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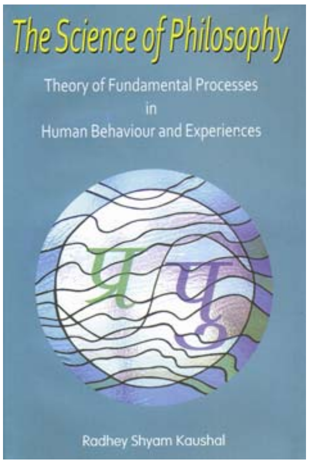

The Science of Philosophy: Theory of Fundamental Processes in Human Behaviour and Experiences. Radhey Shyam Kaushal. D. K. Printworld (P) Ltd, 'Srikunj', F-52, Bali Nagar, New Delhi 110 015. 2011. xxix + 541 pp. Price: Rs 1150/US$ 46.00.

This book attempts the impossible task of integrating science, philosophy, consciousness and religious thought within one single treatise. Since one has specialized only as a physicist, one is conscious of one's limitations in reviewing such a book. The word 'philosophy' literally means the love of truth. Therefore, it includes science, since science is a quest for the truth about how Nature functions. The author quotes Einstein saying, 'If philosophy is interpreted as the quest for the most general and comprehensive knowledge, it obviously becomes the mother of all scientific enquiry'. Perhaps this is why those who do scientific research are still awarded the degree of 'Doctor of Philosophy'. However, science deals mainly with the measurable, whereas philosophy, consciousness and religious inquiry deal essentially with the immeasurable. Basic science, so far as I know, is unable to define what consciousness is or explain how it originated, if at all. The scientist speculates that both life and consciousness are generated as an emergent property when the atoms of matter come into a particular configuration. Erwin Schroedinger made an interesting statement about the ultimate aim of science. He wrote, 'I consider science an integrating part of our endeavour to understand the one great philosophical question which embraces all others: WHO ARE WE? I consider this not one of the tasks but THE task of science, the only one that counts.'

According to the standard model of the origin of the universe, it began with a Big Bang explosion in which energy was in the form of a plasma consisting of quarks, photons, electrons and such elementary particles in random motion. The explosion led to a rapid expansion of the universe and it has continued to expand till now. There could be no life at the origin of the universe since there was no structure and consequently, no consciousness either. The universe of the physicist is a dead universe and the laws of physics do not predict or require the origin of either life or consciousness. According to present scientific knowledge, life appears to have originated accidentally and not intentionally. Consciousness as we know it is believed to have evolved gradually in the course of biological evolution as the structure of the brain became more and more complex.

Religious thinkers fundamentally disagree with this scenario. According to them it is impossible to generate the visible structure in the universe, including life-forms such as our own body, without any intelligence directing the phenomenon. They argue that if it takes intelligence and directed ingenuity to build a computer or a space-vehicle, does it not take intelligence to build a tree or a human body out of the chaotic state of the early universe? So according to religious philosophers intelligence was there first, in the form of a universal consciousness (as distinct from our personal psyche)