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# Perceptions and Acceptance of Public Risks

**James Hutton**
(The Founder of Modern Geology)

(1726-1797)



... think scientifically, act scientifically... think scientifically, act scientifically... think scientifically, act...

# Wetlands as a medium of learning and communication: An intro.

Dr. R. Gopichandran

The United Nations General Assembly in September 2012 recognised the importance of the impetus on "The future we want" and articulated a resolution on the vision and approaches[1]. This included renewed political commitment to help fulfil the goals of collective action, coherence and preparedness to tackle new and emerging challenges. One of the most important aspects of this coherence is the urgent need to engage stakeholders including citizens in information sharing and capacity building for well-informed action. Sustainable development goals and approaches have to be embedded within the frameworks of science and technology communication, so that the messages are received in their true and holistic perspectives. A typical case in point is the management of wetlands with direct implications for sustainable management of resources and livelihoods of people who depend on such systems.

Wetlands provide a unique setting for science communicators, especially in the context of coastal areas. The juxtaposition of land areas and water bodies between fresh, saline and transition systems reinforce this uniqueness. Inflows of waste further enhance the complexity of wetlands. These however help understand the diversity of ecosystem services that wetlands provide. This has also been re-emphasised by the Ramsar Convention[2] and the Convention on Biological Diversity[3]. India recognises the importance of these frameworks and is well-set to reinforce her legal institutional and technical interventions for sustainable use and benefits through ecosystems services. The recent briefing paper of the Centre for Science and Environment[4] draws attention to the draft plan of the Nation Capital Regional Planning Board with special focus on lakes and ponds. This includes surface reservoirs and recharge basins for ground water.

The objective of indicating the above, from a science and technology communication perspective, is to highlight the fact water bodies provide a dynamic setting to help stakeholders understand the nexus between actions and impacts relevant for common good and that these can be reinforced through insights from real-life investigations regarding the phenomena. The time-frames over which activities pertaining to the Rio+20 agenda and even of action plans of urban authorities and management entities are to be implemented are large enough to develop and implement comprehensive communication strategies. These water bodies accordingly provide opportunities to understand the implications of public policies and role of the individual to engage in preventive action. The most important aspect is the local connect that can be easily visualised by the learners and the communicators. Such larger aspects as the local and regional impacts of climate change-related environmental characteristic can also be demonstrated. While water bodies accordingly provide dynamic windows of opportunity for learning, it is only logical to appreciate that other environmental resource entities, too, provide unique opportunities for real-life learning. A large number of community initiatives and well documented communication experiences will also be available for easy access. It is important to capture the best out of these to strengthen communication and learning process.

The East Kolkata wetlands are a typical case in point. It receives millions of litres of sewage every day. This sewage is transformed through natural ecological process and helps sustain diverse fisheries and related activities. Thousands of people derive livelihood benefits from these wetlands and in this process are interconnected with the variety of ecosystem services provided by the wetlands. Similarly, several other wetlands across the country are based on either fresh water or estuarine systems and are therefore unique as learning models.

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# James Hutton

## The Founder of Modern Geology

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"The Hutton's theory, based on systematic observations and thinking, he not only proposed an alternative to the Neptunists, but he also laid down an important principle, for which he is often named the founder of geology. That principle, known as Actualism, proposes that the Earth's surface was formed by forces—erosion and volcanoes—that were still active in modern times and could still be observed. It is closely linked with a principle known as uniformitarianism, further developed in the following century by Lyell, which combines Actualism with several other factors to form many of the basic premises on which modern geology is based."

Ray Spangenburg and Diane K. Moser in *The History of Science in the Eighteenth Century*, 1993.

"Hutton is widely regarded as the founder of geology as a modern science. He rejected the scriptural time scales hitherto accepted, which dated the earth as only a few thousand years old, and argued that it was immeasurably ancient, with 'no vestige of a beginning, no prospect of an end'. He considered the erosive action of rivers to be a major agent in creating continental topography and believed that sediments washed into the sea by rivers to be accumulated and were metamorphosed via geothermal heat to form new rocks, which would eventually be uplifted and form new land masses."

*The Cambridge Dictionary of Scientists*, Cambridge University Press, 2002

"A long time scale is essential to Hutton's theory of uniformitarianism as the forces of erosion and combustion work, in general and slowly, as demonstrated by the presence of visible Roman roads. He concluded that on the face of the Earth 'we find no vestige of a beginning—no prospect of an end…In the 19th century Charles Lyell expanded the theories of uniformitarianism and these were to influence Charles Darwin in his theory of evolution."

*A Dictionary of Scientists*, Oxford University Press, 1999

James Hutton is known for his theory of the Earth, which has earned him the title of 'founder of modern geology'. Thus Rachel Laudan wrote in the *Oxford Companion to the History of Modern Science*: "Charles Lyell made Hutton the hero of the influential introduction to his *Principles of Geology* (1830), and Archibald Geike, in his *Founders of Geology* (1901) treated Hutton as a founding father of the discipline. Hutton thus came to be seen as the founder of modern geology, a Plutonist, a uniformitarian, and a hard-headed, no-nonsense scientist reporting what he saw in the field, untouched by religious pre-conceptions. In the mid twentieth century, historians of science have tried to put Hutton back into his intellectual context in the Scottish Enlightenment." The approach adopted by Hutton to study the Earth established geology as a distinct discipline of modern science. Hutton proposed that Earth was continuously being formed by cycles of rock formation and deformation. He believed such geological cycles had been completed many times. Hutton realised that the Earth must be very old. He also realised that the history of the Earth could be determined by the geological processes operating today.

*James Hutton*

Hutton proposed that the fundamental force behind rock formations was the subterranean heat. According to him high pressures and temperatures at great depths within the Earth could induce chemical reactions to form basalt, granite and mineral veins. Hutton demonstrated the existence intrusive igneous rocks for the first time as a new class of rocks. He proposed that all igneous rocks originated in a sub-crustal zone of unknown depth. Hutton called this region 'the mineral region' and this region was thought to possess enough heat to melt rocks.

Hutton's theory of the Earth is also called 'Plutonism' (named after the Roman god Pluto ruling over the lower world) or 'Vulcanism' (named after Vulcan, the Roman god of fire and metalworking). The followers of Hutton's theory were called 'Plutonists' or 'Vulcanists'. The theory proposed by Hutton came into direct opposition to the earlier theory proposed by Abraham Gottlob Werner (1749-1817) to explain the history of the Earth. Werner explained the surface of the Earth and the distribution and sequence of rocks by taking recourse to a deluge which had covered the entire Earth including the highest mountains. According to the Werner's theory the rock formations took place after the flood receded in a universal and specific sequence. The theory of Werner is also called 'Neptunism' (named after the Roman god of the sea and its followers 'Neptunists').

Hutton's interest was not confined to geology alone. Besides being the founder of modern geology, Hutton was a doctor, agriculturist, mineralogist, chemist and philosopher. Hutton also took interest in other branches of science namely chemistry, physics and meteorology. He described his ideas on meteorology, phlogiston, cohesion,

light, heat, electricity, and nature of matter in a three-part book entitled *Dissertations on Different Subjects in Natural Philosophy* (1792). He displayed serious interest in agriculture and he himself did farming for some years. He undertook the writing of a book on agriculture entitled *Principles of Agriculture*. He nearly completed the book and left it in manuscript form. This remained unknown until 1947 when it was published; that is, after 150 years Hutton wrote it. The manuscript shows Hutton's insightful observations on subjects like soil formation and its fertility, the impact of manure on crop yields and selective breeding of crops.

*Charles Lyell*

Hutton also took interest in the philosophical inquiries of his time. He described his philosophical ideas in his work *An Investigation of the Principles of Knowledge, and of the Progress of Reason—from Sense to Science and Philosophy* (1794).

James Hutton was born on 3 June 1726 in Edinburgh, Scotland. His father William Hutton was a wealthy merchant, who became the Edinburgh city treasurer. William Hutton died when James was only about two years old. James and his three sisters were bought up by his mother Sarah Hutton (*nee* Balfour). James had an elder brother but he died young. James' mother had no financial difficulties in raising the family.

James Hutton entered the Edinburgh High School in 1736 at the age of ten. At the school he studied Latin, Greek and mathematics. At the age of fourteen (November 1740) Hutton entered Edinburgh University, where he studied mathematics and natural philosophy. He was taught mathematics by Colin Maclaurin, a well-known Newtonian exponent. It was Maclaurin, who had known Isaac Newton, made Hutton familiar with Newton's ideas of universal laws and method of science for unravelling the mysteries of nature. He also became interested in chemistry but at that time Edinburgh University did not offer any course on the subject. After graduating from Edinburgh University in 1743 he became an apprentice to a lawyer. However, as he was not interested in pursuing law as a career he returned to Edinburgh University in November 1744 to study medicine. After studying three years at Edinburgh, Hutton moved to the University of Paris and from there he again moved to Leiden University. In 1749, he obtained his degree of doctor of medicine of Leiden University. After finding that there was not much scope he opted out of the medical profession. He decided to engage himself in agriculture. To equip himself for the job he went to Norflolk to get practical training in farming. He also visited Holland, Belgium and France for making himself familiar with the agricultural practices in those countries.

*Colin Maclaurin*

In 1754, Hutton moved to Berwickshire, where he had inherited a farm from his father. At Berwickshire he began farming and lived there till 1767 when he returned to Edinburgh. While deeply engaged in farming he also continued to work on his theories of geology.

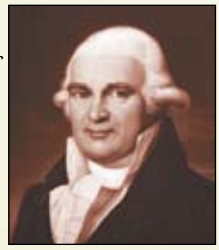
In 1785, Hutton presented his views to the newly established Royal Society of Edinburgh in a paper entitled *Theory of the Earth, or an Investigation of the Laws Observable in the Composition, Dissolution and Restoration of Land upon the Globe*. This paper appeared in print in 1788 in the *Proceedings of the Royal Society of Edinburgh*. He elaborated his theory in greater detail in his classic work, *The Theory of Earth, with Proofs and Illustrations*, which was published in two volumes in 1788. He also worked on a third volume to complete his work. This was not published and it was left in manuscript form. A part of this manuscript given by Leonard Horner was published by the Geological Society of London in 1899. The manuscript was edited by A. Geike. The remaining portion of the manuscript appears to be lost.

Hutton's paper and book was not well received, as his writing style was very peculiar and it was not easy to follow. Commenting on his difficult writing style John Playfair wrote: "The reasoning is sometimes embarrassed by the care taken to render it strictly logical; and the transitions, from the author's peculiar notions of arrangement, are often unexpected and abrupt. These defects run more or less through all of Dr. Hutton's writings, and produce a degree of obscurity astonishing to those who knew him, and who heard him every day converse with no less clearness and precision than animation and force. From whatever causes the want of perspicuity in his writings proceeded, perplexity of thought was not among the number; and the confusion of his ideas can neither be urged as an apology for himself, nor as a consolation to his readers."

*John Playfair*

Playfair was a professor of mathematics at the University of Edinburgh and a friend of Hutton. He took it unto himself the task of spreading Hutton's ideas. He had a flair for writing. In his classic work, *Illustrations of the Huttonian Theory of the Earth* (1802), Playfair presented an excellent summary of Hutton's theory. He also added numerous illustrations and arguments. Playfair also published a biographical account of Hutton in the Transactions of the Royal Society of Edinburgh in 1805.

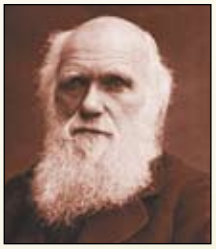
Before Hutton, Abraham Gottilob Werner had proposed a theory of the Earth. Werner's first basic premise was that the Earth was originally covered entirely by a vast, muddy primeval ocean created by the Biblical Flood. This flood had covered the entire Earth including the highest mountains. The huge quantities of materials suspended within this primeval ocean gradually crystallised onto the seabed as primitive rocks with the declining of the sea level. This layer consisted of primitive rocks such as granite, gneiss and slates and contained no fossils. According to Werner the primitive rocks thus formed were the universal formation, which constituted the entire original surface of the Earth. The next higher layer included shales, greywacke, and fossilised fish, then followed limestones, sandstones and chalks of secondary rocks, and finally sands and gravels of the alluvial strata. Werner further proposed that the sea level continued to decline and eventually the waters had completely disappeared and after this local volcanic activity produced lavas and other deposits.



*Abraham Gottlob Werner*

Hutton's account of the Earth was

very different from the Biblical account according to which the Earth came into existence only around six thousand years ago by a catastrophic account. Hutton proposed that the Earth was formed by continuous cycles in which rocks and soil are formed and deformed. Hutton after making a wide range of observations came to the conclusion that soil was formed by the degradation of rocks by weathering, which in turn was further eroded over time to mobile sediments and was transported to the sea where it formed sediments and hardened. Hutton realised that there must be some natural process to uplift the newly formed sediments again. In the absence of such a process all land would eventually be carried to the sea and a time would come when there will be no land left. But the fact is that the land never went below the sea level. Based on his observations Hutton worked out the key steps of a cycle in which lands are formed and deformed and in this way he developed many of the ideas associated with the rock cycle. This cycle is now called 'rock cycle'. The steps of the rock cycle worked out by Hutton are:



*Charles Darwin*

- Weathering: rocks are converted into soil.
- Erosion/transportation: soil is eroded into a form (mobile sediment) which can be carried away.
- Deposition: sediments get deposited in the sea in layers to form sedimentary sequences.
- Compaction/cementation: sediment deposit at the bottom of the sea is hardened to form sedimentary rocks.
- Metamorphism: metamorphic rock is formed by heat.
- Melting: igneous rocks become molten magma by excessive heat.
- Crystallisation: magma gets crystallised into igneous rocks.
- Uplift: different types of rocks like igneous, metamorphic and sedimentary are uplifted from time to time to form new land.

Hutton realised that several cycles would be required to form the surface of the Earth and for this to happen a very long interval of time would be required. Thus Hutton concluded, "We find no vestige of a beginning, no prospect of an end."

Hutton's contribution goes beyond merely working out most of the rock cycle. He proposed that rock formation can be explained by the same geological processes that are operating on Earth today. This concept was later called the Principle of Uniformitarianism. It is a very important contribution to geology. Principle of Uniformitarianism can be simply stated as 'the present is the key to the past'. According to this principle the geological forces at work at the present are the same as those that operated in the distant past. While these geological forces have immense impact but they are hardly noticed by human beings. The Principle of Uniformitarianism implies that the rates at which geological processes such as erosion or sedimentation occur today are similar to the rates at which they operated in the past. This means that we can estimate the time of deposition of rock for example sandstone of a given thickness.

From his book on agriculture it appears that Hutton had anticipated the theory of Natural Selection later proposed by Charles Darwin. He wrote in *Principles of Agriculture*: "To see this beautiful system of animal life (which is also applicable to vegetables) we are to consider, that in the infinite variation of the breed that form best adapted to the exercise of those instinctive arts, by which species is to live, will be the most certainly continued in the propagation of this animal, and will be always tending more and more to perfect itself by the natural variation which is continually taking place. Thus, for example where dogs are to live by the swiftness of their feet and the sharpness of their sight, the form best adapted to that end will be the most certain of remaining, while those forms that are least adapted to this manner of chase will be the first to perish; and the same will hold good with regard to all other forms and faculties of the species, by which the instinctive arts of procuring its means of substance may be pursued."

Commenting on Hutton's personal traits, John Playfair wrote: "to his friends his conversation was inestimable; as great talents, the most perfect candour, and the utmost simplicity of character and manners, all united to stamp upon it…The simplicity pervaded his whole conduct; while his manner, which was peculiar, but highly pleasing, displayed a vivacity, hardly ever to be found among men of profound and abstract speculation. His great liveliness, added to the aptness to lose sight of himself, would sometimes lead him into little eccentricities, that formed an amusing contrast with the graver habits of philosophic life. …But it is impossible by words to convey any idea of the effect of his conversation, and of the impression made by so much philosophy, gaity and humour, accompanied by a manner at once so animated and simple."

Hutton died on 26 March 1797 in Edinburgh, Scotland.

Some important books on the life and work of James Hutton are: (1) *James Hutton: The Founder of Modern Geology* by Edward Battersby Bailey, Elseiver, New York, 1967; (2) *James Hutton and the History of Geology* by Dennis R. Dean, Cornell University Press, 1992; (3) *James Hutton: The Founder of Modern Geology* by Donald B. McIntyre and Alan McKirdy, The Stationary Office, Edinburgh, 1997; (4) *The Man Who Found Time: James Hutton and the Discovery of the Earth's Antiquity* by Jack Repcheck, Perseus Publishing, New York, 2003; and (5) *Ages in Chaos: James Hutton and the Discovery of Deep Time* by Stephen Baxter, Macmillan, 2004.

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*(The article is a popular presentation of the important points on the life and work of James Hutton available in the existing literature. The idea is to inspire the younger generation to know more about James Hutton. The sources consulted for writing this article have been listed. However, the sources on the Internet have not been individually listed. The author is grateful to all those authors whose writings have contributed to writing this article. The author is also grateful to the sources from which the illustrations/photographs have been reproduced.)*

# Perceptions and Acceptance of Public Risks

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Let me start with some recent newspaper headlines which I found somewhat disturbing.

I. Public agitation against the Koodankulam nuclear power project
II. National moratorium on Bt Brinjal
III. Inter-state controversy over the Mullaperiyar Dam

The Nuclear Power Corporation of India is building two 1,000-megawatt nuclear power plants on Tamil Nadu coast at a cost more than Rs.10,000 crores. The plants have been under construction for nearly a decade and are almost ready for commissioning. Suddenly, there is a public uproar against the safety of the plants, presumably in the backdrop of the Fukushima nuclear event, with a demand that the project be scrapped. Repeated assurances by the experts do not seem to be convincing the agitators. That this country cannot afford to say NO to nuclear power is also not convincing to the agitators.

The Bt brinjal is suite of transgenic brinjals created by inserting a crystal protein gene from the soil bacterium *Bacillus thuringiensis* into the genome of brinjal cultivators. The Bt brinjal has been developed to give resistance against specific insects, in particular the brinjal fruit and shoot borer. The Bt brinjal was approved for commercialisation in India in 2009, but after a public outcry, the Indian government applied a moratorium on its release.

The Mullaperiyar Dam is a masonry gravity dam on the Periyar River in the Kerala state. The dam was constructed between 1887 and 1895 by the British Government to divert water eastward to Madras Presidency area, the present-day Tamil Nadu. The dam and the river are located in Kerala but the dam is controlled and operated by Tamil Nadu state under a period lease. The dam is an 'endangered' scheduled dam under the Kerala Irrigation and Water Conservation (Amendment) Act, 2006, the control and safety of the dam and the validity and fairness of the lease agreement have been points of the dispute between Kerala and Tamil Nadu states.

All the above projects are clearly in public interest but acceptable public risks as perceived by a section of the population are prompting them to agitate against the projects. Repeated assurances by the specialists do not seem to be cutting ice with the agitators. It is also unrealistic to expect full consensus in matters of public perception. Are the long term interests of the country being compromised by these agitators? What is the way forward?

One would be tempted to say "Well, it is the responsibility of the government to protect the interests of the public and take appropriate decisions based on a majority view". There are two wings of the government that are mandated to take decisions in public interest – the bureaucracy and the elected representatives. What are their past records? Let us take two examples – the introduction of Euro-II cars and CNG in Delhi. Both these decisions came through judicial interventions, neither executive nor legislative interventions. One might say after all, we are democracy. Let the people decide".

*As far as safety is concerned, the Russian-built VVER-1000 reactors set up at the Kudankulam Nuclear Power Plant have some of the most advanced safety features. The reactors have a unique passive safety feature which provides cooling to the nuclear fuel without the need for operator action or power supply.*

But the question is: "Is the public informed enough, particularly on issues that are highly technical?" especially when there is no consensus? Are there channels to express and force their choices other than the periodic elections? How to protect the system from vested interests? This indeed is a challenge to the democracies.

Let me start with a simple analysis of our day-to-day decision making processes. We are all used to a cost-benefit analysis in most of our decisions. When the decision also involves a risk, a risk-benefit analysis also becomes important. The issue becomes important if costs, benefits and risks are spread over a long period of time. Sometimes, the costs of not making the right decision at the right time also becomes important and has to be taken into account in the decision making process. All of us make such choices in our day-to-day life almost on daily basis.

Let me take for example the purchase of a house that most of us have done at some time or another. We need to worry about the cost, the rental value, anticipated appreciation, potential risks, etc. Some of us have delayed the decisions for so long that we lost golden opportunities that we repent later. Sometimes, the costs or the risks need not all be beneficial. Take the case of adventure sports like bungee jumping. While the costs are financial, the benefits are psychological and the risks are extreme.

When the choice involves matters of new and emerging technologies, the choice indeed becomes complex. I always say don't offer to buy a colour television or a cell phone to your family because by the time you purchase the item, it is already out-of-date and you may be open for ridicule. In some areas like the emerging stem cell therapy, we are as ignorant as any other non-specialist. But in all these cases, the costs, benefits and risks are confined to individuals or a small group of people like a family and we make choices. When the costs, benefits and the risks are not limited to an individual or a family but involve the

*Building of the Rihand dam near Pipri in the Sonbhadra district of Uttar Pradesh displaced around 2,00,000 people. However, due to a misjudgment of the catchment area, people had to move again as reservoir area expanded in the early 1960s. In 1975, people were again displaced for the NTPCL Shakthinagar thermal project.*

public at large, the decision making process is indeed very complex and may involve not only financial and technical but also ethical and moral issues. More importantly, the population benefitting from the choice may not be the one that bears the costs and risks. In such cases, it is nearly impossible to have a consensus, leaving pockets of disgruntlements. They are also open for exploitation by vested interests.

Let me take one well known example – the Singrauli resettlements. The area in the eastern part of Madhya Pradesh and the adjoining southern part of Sonbhadra district in Uttar Pradesh is collectively known as Singrauli. Due to rich coal deposits in the area, Singrauli is often referred to as India's energy capital. A cluster of thermal power plants, both government and private owned, dot the area with a declared potential for 35,000 MW of generation capacity. The history of displacement in this area is indeed revealing. The entire area of Singrauli was originally covered by dense forest. The river, Rihand, dammed in late 1950s (Govind Vallabh Pant Sagar Dam) to create an artificial lake called the Rihand reservoir.

The building of the dam displaced around 2,00,000 people. However, due to a misjudgement of the catchment area, people had to move again as reservoir area expanded in the early 1960s. In 1975, people were again displaced for the NTPCL Shakthinagar thermal project. Not only tribals were disproportionately affected but the so called compensatory development had little to talk about – no schools, no health centres, no roads, not even electricity and clean drinking water. Very high unemployment among the displaced communities has also been noted. It is not surprising that in 1993, a proposal to expand the Rihand Ash Dike through World Bank financing met with stiff resistance from the villagers.

The pattern is replicated across India, souring relations between the government, corporate, NGOs and the public. In contrast, there are important lessons to be learnt in another case – relocation of Yeravadi tribes in Sriharikota., the hub of India's space launch programme. By a conscious decision, the strategy was to co-habilitate rather than rehabilitate the locals which made them partners. The island has seen no conflicts in the last few decades.

*For building the Sriharikota satellite launching facility, the hub of India's space launch programme, it was consciously decided to co-habilitate rather than rehabilitate the local Yeravadi tribes, which made them partners. The island has seen no conflicts in the last few decades.*

during the last few decades. One may also recall some of the recent discussions on human-animal conflicts where even ethical and moral issues surface. Sometimes, especially in the case of new and emerging technologies, neither the cost nor the risks can fully be enumerated. A hope to arrive at a consensus through truly democratic means is indeed a utopia. We also seem not to learn from our past experiences.

While costs, benefits and the risks at the public level are all complex, risks are even more complex. The insurance people have always been doing risks analysis, but mostly based on past experiences. We all know that risk perception is a highly personal affair. It is said that pleasure and pain are personal and subject to individual experience. It could be your own experience or that of your close ones. Risk defined as unexpected pain is no exception and is highly personal. On the other hand, personal experiences, however extensive they are, cover a miniscule of risks one faces in one's life time. Risk perceptions are therefore not always logical, they are often psychological.

Much of superstitious beliefs and phobias that one sees around belong to this class. I was surprised to discover at the age of 60 that I am afraid of space constrictions during my visit to Cu Chi tunnels in North Vietnam. Technology risks are even more complex. Sometimes these risks are totally futuristic. Risk communication therefore plays a very important and challenging role in moulding individual risk perceptions, especially when the risks are of technical, futuristic and probabilistic. It is also important to note that not only media play a major role in moulding risk perceptions but they are also most effective on the younger population. On matters that depend on public perceptions, I believe that wide-spread contact with the student community is the most effective way of communication.

Risk acceptance is even more complex. Acceptance at personal level is highly individualistic. I mentioned about adventure sports where even a risk to life is willingly taken. Risk acceptance at the personal level and at the collective level need not be the same. At the collective level, sociology and culture play a very important role in defining public risk acceptance.


*The British De Havilland Comet was the first commercial jetliner in the world, but first few years of experience with Comet jet engines in the 1950s were disastrous with a series of accidents, which made Britain "say no to jet engines" and miss the opportunity to be the world leaders in this technology though they were the pioneers.*

Let me ask you a simple question: "What is the most serious risk to life that an average Delhi resident faces?". Is it pollution, terrorist attack, acts of war, natural disasters like floods and earthquakes, traffic accidents, or anything else? Following the devastating earthquake in Bhuj, I had received an international delegation to discuss strategies for earthquake proofing Delhi. One of the delegation members remarked that the biggest risk that an average Delhiite faced was fatal traffic accidents. He was wondering why India is paying so little attention to regulating traffic while worrying about a possibility of an earthquake. Clearly, public perceptions and acceptance of risks differ widely. Here again, media can play a major role, but a sustained campaign and demonstrated compensatory benefits to offset the risks accepted are more likely to be effective.

Sometimes it is argued that why should anyone opt for a risky choice at all? Why can't we take only safe choices? At the outset, we all know that there is nothing that is absolutely safe. More importantly, a safe choice of today may not remain so over a period of time. On the other hand, a risky choice of today may turn out to be safer in course of time. Let me take the example of jet engines for passenger travel. The first few years of experience with Comet jet engines in the 1950s were disastrous with a series of accidents. We now know why, but at that time the feeling was "say no to jet engines". Great Britain precisely did that. Fortunately the world didn't and moved forward. Britain lost the opportunity to be the world leaders in this technology though they were the pioneers.

When India introduced the fly-by-wire aircrafts, A-320, in the early nineties, we opened our account with the air crash on the outskirts of Bangalore. The memory of another A-320 air crash in 1988 in Habsheim, France in the prestigious Air Show was still fresh in our memory. We grounded the entire fleet of A-320's for a long period, but fortunately resumed after convincing ourselves that there was no safety issue with the aircraft. In fact, our airports were underprepared to exploit some of the safety features of the aircraft. When our airports were ready, still an accident took place in Mangalore. They said "Ah, the pilot was sleepy". When they were negotiating with the pilots, yet another aircraft landed on the nose wheel. They said "Ah, the pilot had a fake certificate". When DGCA is tightening the licensing procedures, I continue to travel by air. My wife believes that the road journey to the airport is more risky than the air journey itself! Any time I overhear someone whispering "Solpa adjust maadi" (which in Kannada roughly translates to "Please adjust a bit."), I feel a chill in my spine. Still I take the plane knowing fully well that anything can happen but the balance of advantage lies in utilising this technology while continuously upgrading the safety features.

*One of the first fly-by-wire aircrafts, A-320 that was inducted into Indian Airlines in the early 1990s crashed on the outskirts of Bangalore during landing, leading to the grounding of the entire fleet of A-320's for a long period. But there was no safety issue with the aircraft.*

In contrast, one accident in the early days of airship development led to complete denial of this technology for public use. While we are discussing a ban on the use of helicopters in the North-Eastern states, it hurts to think that the airship could have provided a safer option. The message is clear. The answer does not lie in saying NO to any technology option in our search for an absolutely safe option. Such an absolutely safe option does not exist either. We need to continuously evaluate the advantages and the risks and prepare the public to take informed options.

What is the dynamics of public risk perception and public risk acceptance? How does one translate financial and technical risk assessment into public perceptions? How do public perceptions mould public acceptance of the risks? What is the role of media in this? These are complex issues that warrant and interdisciplinary research and debate. Unfortunately, neither the research funding agencies nor the mandated departments support such multidisciplinary research and advocacy.

National Institute of Advanced Studies (NIAS) has a unique advantage in having technologists, sociologists, psychologists and even philosophers under one roof with no walls and is ideally placed to analyse and understand public risk perception and public risk acceptance. We recently had a two-day brainstorming session as our first effort to understand public risk from a multidisciplinary perspective. In due course we hope to contribute to the policy making process in matters not only of new and emerging technologies but also in matters of social conflicts. The INSA Science and Society Unit can play a proactive role in promoting such studies.

Prof V. S. Ramamurthy is presently the Director of the National Institute of Advanced Studies (NIAS), Bangalore. He is a well known Indian nuclear scientist with a broad range of contributions from basic research to science administration. During the period 1995-2006, Prof Ramamurthy was fully involved in science promotion in India as Secretary to the Government of India, Department of Science & Technology (DST), New Delhi.

# Mathematics and its Exactness

Dr. C.K. Ghosh[1] Dr. B. Chakrabarti[2]

> The things of this world cannot be made known without a knowledge of mathematics.
>
> *-Roger Bacon.*

## Introduction

Mathematics is one of the oldest branches of knowledge. It may look more abstract today but it actually evolved as a practical necessity when the branches like arithmetic and geometry first began. The exactness of mathematics may appear to be a unique characteristic of the subject. This article aims at establishing this notion of exactitude of mathematics. It also brings home the point that the apparent departures from exactitude do not pertain to the domain of mathematics but to the branches of science which use mathematics as their language of analysis and expression.

## Background

Arithmetic and geometry are the two main branches of mathematics that developed during the period of ancient civilisations as both had applications in everyday life situations in a big way. They were definitely the outcome of the critical reasoning of some of the outstanding minds of ancient civilisations, but these should not be construed as some intellectual exercises in isolation. Though geometry was mainly the handiwork of the Greeks and Babylonians, arithmetic flourished in other ancient civilisations like those of India and China. Astronomy could actually develop as a branch of science when celestial observations fascinated people from ancient civilisations and made them start looking for the reasons behind the phenomena. Subsequently with the help of mathematical calculations people tried to predict the behaviour of the celestial objects, as it was realised that they follow a rule, the so-to-speak '*the law of nature*'. The ability of mathematics to handle real life situations through calculations and the scope of their validation through experimental work indeed made it a very special branch of knowledge. This really started a notion among the students and teachers that mathematics is essentially exact and its real beauty lies there.

## Examples of exactitude

In the ancient world two very important areas were dependent on mathematics and the subject used to be of great help. The first one was the measurement and construction related calculations where both geometry and arithmetic used to go hand in hand. The ancient architectural marvels like Flying Buttresses at the Rheims Cathedral in Paris, and the Pallazzetto dello Sport in Rome[1] testify this interplay between geometry and arithmetic. The second activity in a way was more common and it involved trading, maintenance of accounts, etc., which were solely dependent on arithmetic. Thus both the branches started getting refined and the notion about the exactness of mathematics grew. Let us substantiate our observations with a few examples.

Let us consider the case of a knock-out tournament. If the total number of participants is $N$, how many matches will the tournament organising committee have to arrange for? For a tournament like the Wimbledon, $N$ is always of the form $2^n$. In the first round there are 128 (men's singles or women's singles) players, i.e., $2^7$, so there are $2^7 \div 2 = 2^6$ matches. Likewise, in the second and third rounds there are $2^5$ and $2^4$ matches respectively. Then comes the pre-quarter final and quarter-final stages where there would be $2^3$ and $2^2$ matches, and in the semi-final the number of matches will be $2^1$ or just two matches to decide on two finalists. The final is only one. i.e., $2^0$ match. So the total number of matches is $2^6+2^5+2^4+2^3+2^2+2^1+2^0 = 127 = 128 - 1$; that is, one less than the total number of participants.

Now, is it true only in case of the total number being of the form $2^n$? Let us examine that. In case of a tournament of the stature of Wimbledon, it is ensured that at the final stage the number of participants is of the form $2^n$. But suppose a knock-out table tennis tournament is organised in a school. Say the total number of participants is 110, which is not of the form $2^n$. Then what would be the number of matches? In a knock-out tournament, a player or a team which loses is knocked out and it does not return to play any further. Thus every match uniquely determines a loser. Now, in a tournament involving 110 players, only one will be the champion and so the remaining 109 would be losing at some stage or the other. Since there are 109 losers, the total number of matches to be organised is 109, which is 110-1. Thus, if the total number of participants is $N$, the number of matches would be $N$-1. This is an example where the logic of arithmetic ensures exactness.

Let us now take up the issues of the standard times of the different countries of the world. The international agreement in this regard is that the difference of time between any two countries must be a multiple of 30 minutes. Now, what does it imply?

The Earth takes about 24 hours, i.e., 1,440 minutes to complete one rotation about its axis. Thus, 1,440 minutes is the duration for turning through 360°. In other words, 1,440 minutes is equivalent to 360°. So we can apply unitary method to obtain that duration of 30 minutes in equivalent to a rotation of 7.5 degrees. So it is essential that the standard time is determined with reference to such a place whose longitude is a multiple of 7.5 degrees. It is not always feasible. For example, in Nepal and Sri Lanka it is not possible and so some adjustments have to be made. However, for India it is Mirzapur, near Allahabad the longitude of which is approximately 82.5° E, and 82.5 is indeed a multiple of 7.5 (82.5 = 11x 7.5). Thus Indian Standard Time is 11 x 30 min = 330 min or 5 hours 30 minutes ahead of Greenwich. So it is yet another example where mathematics provides exactness.

## Probabilistic approach

In a game of bridge suppose the total number of cards of spades between you and your partner is nine. An estimate of the break-up of the remaining four cards with your opponents is quite crucial in respect of the strategy of your hand play. The break-up can be (4+0), (3+1) or (2+2). The number of ways these can happen are

$$\frac{4!}{4!0!} = \frac{24}{24.1} = 1$$

$$\frac{4!}{3!1!} = \frac{24}{6.1} = 4$$

$$\frac{4!}{2!2!} = \frac{24}{2.2} = 6$$

So the chance of a (4+0 ) break is 1 in 11, and those of (3+1) and (2+2) break are respectively 4 in 11 and 6 in 11 . So the most likely break-up is (2+2), but it does not mean that the break-up is indeed (2+2). You may play your hand expecting a (2+2) break, but it may turn out to be otherwise. Such an outcome follows from mathematical analysis, provided that the situation is probabilistic. The probabilities of various possibilities can be calculated exactly, but the calculation cannot fix the possibility.

## Issue of accuracy

When people began to undertake the act of verification of different measures as predicted by mathematics and its rules, they began to realise that the exactness of mathematics though always applicable, may not be appreciable in real life. That, however, does not mean that there was some flaw in the concept of exactness in mathematics. The reason is that real life measurements contain what in today's parlance is known as uncertainty[2]. For this the mathematically predicted results can only be attained inexactly with some so-called 'error', or to be more correct, with certain degree of 'uncertainty'; that is, there would be departure from exactitude. And some mathematical predictions may lead to some sort of unattainable situations as well. Let us elaborate these two points with an example for each.

Let us start with two very simple arithmetic problems that most of us must have handled in our school days. The first one is like this. Let us consider a rectangular ground whose length is 80 metres and breadth is 60 metres. And the question is, what is the area of the ground? Well, quite a trivial question! If a student writes the area as 4,800 sq metres, full marks will be awarded to her. But if measuring tapes are given to her to find out the area of a real ground of similar size through measurements then it would allow her to check the calculated value. And this measured value will be close to the calculated or predicted value but most unlikely will be exactly equal to the value calculated from the mathematically correct formula.

There may be several reasons for this. First, the ground is most unlikely to be exactly rectangular. In fact, a ground of that dimension with exact rectangular shape is difficult though not impossible to obtain. And then comes the question of getting the exact length and the exact breadth. Then we need to consider the least count of the measuring tapes. The theoretically framed question has the background that the length is exactly 80 metres without mentioning or without bothering about the measuring device. So one has to accept that the length is 80 m even when one is having a measuring device that can measure say up to 1mm, leave aside any fraction of that. We are not going to raise any question about the skills and abilities of the young students, but the measurement will yield a result that will be close to the calculated value but not exactly equal to the one that has been calculated on paper. And once again this is nobody's defect. Physicists will be happy to accept it as an error in measurement; an inseparable entity associated with experiments in physics or for that matter any experimental activity.

## Problems related to unitary method

This example pertains to the unitary method. If 12 persons working 8 hours a day can build a hut in 6 days, then how many persons will you need to complete the work in 2 days if they work 9 hours a day? Well, this is a rather common problem in unitary method and we can have the answer quite easily. But the interesting aspect lies elsewhere.

We have never questioned, rather we have never been allowed to question whether this is possible in reality. For example, if we employ more workers can we complete the hut in a day or for that matter in a few hours? Well, arithmetic does not forbid that. But what does experience tell us? There are certain sequences of hut-building. You cannot put the roof before you have erected the walls or poles that will support it. The plinth has to be made first. If one employs large number of people some would be compelled to sit idle at the beginning as all of them cannot be engaged in digging up the soil because of the inadequacy of working place. In reality, if we consider that the workers employed have better skill only in some parts of the work then the distribution of work becomes difficult. There are similar other points that will really make it impossible to complete the work even in a couple of days irrespective of the number of workers engaged. Does then mathematics fail in a situation like this? No, not at all. Mathematics does its job in an excellent way but the lesser mortals possibly cannot. Mathematics tells us the things in an exact way that we on most of the occasions cannot achieve.

## Introduction of calculus

It is better we look at mathematics in a slightly different way. Particularly after the introduction of calculus the role of approximations and their skilful use through mathematical visualisation is an area that has provided life to physicists, both experimental and theoretical[3]. Otherwise how could we calculate the work done by a variable force that varies with the slightest change of distance? Or for that matter the calculation of area under any odd-looking curve would have posed a very serious problem before us. The inexactness of calculus, if we are at all allowed to say so, is actually a very great advantage in the domain of exactness of mathematics.

We shall now discuss situations which are exact, but the parameters of which defining the situations may not be absolutely compatible to the notion of exactitude.

Let us substantiate this statement by an example. We know that $\tan 45^0 = 1$. Now, what is $\tan 46^0$? A modern scientific calculator gives the value correct up to nine places of decimal as 1.035530314. Now, let us apply calculus to get the value of $\tan 46^0$.

We define,

$f(x) = \tan x$.

We know from Taylor's Series expansion that

$$f(x+h) = f(x) + h f'(x) + \frac{h^2}{2!} f''(x) + \frac{h^3}{3!} f'''(x) + \ldots$$

The above is an infinite series. It in effect shows the progress towards attaining an exact value but it is a never ending quest. In the instant case, we may put

$$x = 45^0 = \frac{x}{4}, \qquad h = 1^0 = \frac{x}{180}$$

$$f(x) = f(\pi/4) = \tan\frac{\pi}{4} = 1$$

$$f(x+h) = f\left(\frac{\pi}{4} + \frac{\pi}{180}\right) = \tan 46^0$$

$$\therefore \tan 46^0 = 1 + \frac{\pi}{4} f'\left(\frac{\pi}{180}\right) + \frac{1}{2}\left(\frac{\pi}{180}\right)^2 f''\left(\frac{\pi}{4}\right) + \frac{1}{6}\left(\frac{\pi}{180}\right)^3 f'''\left(\frac{\pi}{4}\right)$$

$$f(x) = \tan x, f'(x) = \sec^2 x, f'\left(\frac{\pi}{4}\right) = \sec^2\frac{\pi}{4} = \left(\sqrt{2}\right)^2 = 2$$

$$f''(x) = 2\sec\ x.\sec\ x\tan\ x = 2\,sec^2 x\tan\ x$$

$$\therefore f''\left(\frac{\pi}{4}\right) = 2\,sec^2\frac{\pi}{4}\tan\ \frac{\pi}{4} = 2.2.1 = 4$$

$$f'''(x) = 2\,(sec^2 x.\ sec^2 x + \tan\ x.2\sec x.secx\,tanx)$$

$$= 2\,(sec^4 x + 2\,sec^2 x\,tan^2 x)$$

$$\therefore f'''\left(\frac{\pi}{4}\right) = 2\left(sec^4\frac{\pi}{4} + 2\,sec^2\frac{\pi}{4}\,tan^2\frac{\pi}{4}\right)$$

The values of *tan* $46^0$ obtained by applying Taylor's Series expansion are given in the tabular form as under.

| Series up to | Value of tan $46^0$ |
|---|---|
| 2 terms | 1.034906585 |
| 3 terms | 1.035515820 |
| 4 terms | 1.035529998 |

So we see that progressively we reach towards exactitude and it bears testimony to the statement that the inexactness of calculus is a great advantage in the domain of exactness.

Having said about the battle of survival of the feature of exactitude of mathematics in the world of inexactness we shall discuss in the penultimate section about the transcendental numbers, which carry with them an aura of inexactness. But we shall see on the contrary, that these numbers provide exactness galore.

## Transcendental numbers

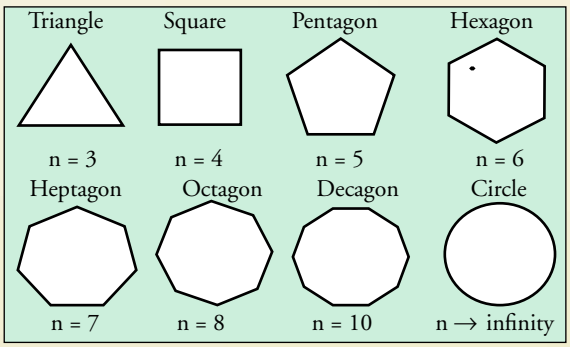
Transcendental numbers are those which are non-terminating, non-recurring decimals and are not capable of being obtained as the roots of equation with rational coefficients. The most prolific examples are pi (π) and *e* (Euler's constant). It is said that mathematics not only deals with but gives huge importance to π and *e*. In every circle, the circumference bears a constant ratio to its diameter. This constant is called (pi). Its approximate value correct up to nine places of decimal is 3.141592654.

And $e = 1 + \frac{1}{1!} + \frac{1}{2!} + \frac{1}{3!} + \ldots to..\infty$

Its approximate value correct up to nine places of decimal is 2.718281828. It is also defined as the limit of $(1+x)^{1/x}$ as *x* tends towards zero.

## Importance of π

Measurement of linear dimension can be done by a scale. But what about curvilinear dimensions? Let us start with the case of a circle of radius *r*. Its circumference is $2\pi r$ and, its area is $\pi r^2$. As a matter of fact, a circle can be visualised as a regular polygon of infinite number of sides (Fig1).




As long as the number of sides are finite, we can manage measurement of lengths, such as perimeter or the area using linear methods. But when the number tends to infinity, thereby taking us to the domain of inexactitude, we have to depend on π for calculation of length, area, etc. In other words the exactness of an apparently inexact situation is handled by making use of π.

## Importance of e

*e* happens to be the basis of logarithm. The natural or the Naperian logarithm (*lnx*) emerged out of the definition of *e*. These days, use of logarithmic table has become virtually obsolete. But the 10-base logarithm got underway through the *e*-base logarithm by application of the base change formula. Moreover, three results of calculus make *e* extremely significant. These are: (i) and (ii) the limits of $e^x$ as *x* tends to plus and minus infinity are respectively infinity and zero; and (iii)

$$\frac{d}{dx}(e^x) = e^x, \qquad \frac{d}{dx}(\ln x) = \frac{1}{x}$$

These relations are the fountain heads of the studies of transient phenomenon in mechanics, electricity, kinetic theory, thermodynamics, radioactivity, statistical mechanics and several other branches.

The Gaussian distribution function is the backbone of several formulations ranging from testing of a hypothesis in statistical analysis to the harmonic oscillator wave function in quantum mechanics. In each of the above cases the crux lies with the asymptotic nature of variation which provides tremendous insight into behaviour of variables tending towards infinity. The very word infinity brings the spectre of some kind of inexactness, but again using *e* as an instrument, mathematics emerges triumphant.

## Conclusion

We have been able to establish that the outcome of mathematics is always exact. The principles involved, at times may appear to be shrouded with inexactness, but it is the beauty of mathematics that the apparent inexactness ultimately drives us towards exactitudes. And the mathematicians' defence, as a student firmly declared, goes like this, "Since we exactly know they are inexact we can make good use of them. Can't you see that?" So sometimes the inexactness also speaks in favour of the exactness of mathematics since that inexactness is so thoroughly known[4]. And mathematics is used as a tool in different branches of science not only with its exactness but with its full range of capabilities that includes the inexactitudes.

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# Dr N Seshagiri: A True Visionary Scientist

**Dinesh C Sharma**
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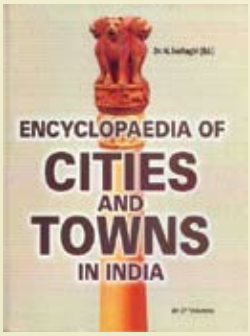
"Computer programming can be done very effectively through interactive terminals and interactive terminals can be put in a home through portable terminals connected to a telephone kind of an outlet. I have myself done it and many of my colleagues have also tried it in the US and other countries……. housewives who have the kind of aptitude for programming and related fields can be made to take up contract jobs for programme development and can do it from their home. The second thing is direct data entry. Any data can be keyed in through keying stations which are remotely located….The third one is text editing by interconnecting sophisticated word processing typewriters… these are typical examples where the type of workforce and the description of jobs can change in the next 10 to 15 years…"

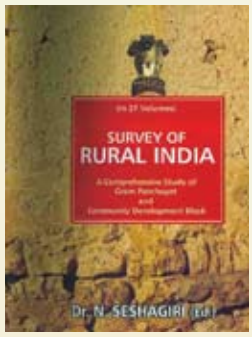
This narrative of teleworking or working with remotely located computers connected via a telecom line is not a description of how India's multi-billion dollar outsourcing industry works in 2000s, but a scenario predicted by a futurologist and technologist in an article written in 1980 before the advent of the PC era, networking era or data transmission via telecom lines or satellites. The technologist was Dr N Seshagiri, who foresaw the future in an interaction on the making of an information society, published in *The Hindu* in December 1980.

*Dr N Seshagiri*

Dr Seshagiri, whose sudden passing away has shocked the technology world, belonged to a unique and rare breed of individuals who combined science, technology, futurology, social good, and science administration. He not only thought of new ideas in science and new ways of technology application but also saw to it that those ideas get accepted by policy makers, are implemented and made an impact on society. His seminal contribution to information technology development in India is an example of this unique capability he possessed.




He was involved at every stage of the development of computing and IT in India, beginning with his career at the Tata Institute of Fundamental Research (TIFR) in 1966 after doing his Ph D in data communication from the Indian Institute of Science (IISc), Bangalore. He was interviewed by Dr R Narasimhan, head of the computer group at TIFR and developer of the first Indian digital computer TIFRAC. One of his first tasks at TIFR was to write a software package called SIMSPACE for sizing of multi-stage rockets using CAD techniques. He also developed operations research software for scheduling bus services of BEST as well as optimisation of electricity generated in the Northern region – nuclear, thermal and hydel. For these projects, he worked under the guidance of Dr Vikram Sarabhai. As secretary of the Department of Atomic Energy, Sarabhai also involved Seshagiri in the work of 'disarmament group. Sarabhai entrusted Seshagiri to study the economics and fallout of a peaceful nuclear explosion, in the backdrop of possibilities of India taking up a PNE. The study was published in *Science Today* magazine under the title 'Peace Bomb'. When India finally exploded the PNE in 1974, Seshagiri was encouraged to bring out the study in the form of a book. It was titled *The Bomb: Fallout of India's Nuclear Explosion* and was published in 1975.




The influence of Sarabhai – who came from a business and industrial background - on Seshagiri was immense, particularly in the area of using technology for industrial and public purposes. This changed outlook of Seshagiri continued throughout his careers in various capacities at the Electronics Commission and the Department of Electronics where he was part of the policy making think tank called Information, Planning and Analysis Group (IPAG). The group wrote technology forecasts, status of technology as well as economic and industrial fallout studies on every segment of the industry. Some of these reports were used by entrepreneurs to start industrial units. Hindustan Computers Limited (HCL) was one such.

Seshagiri was also deeply influenced by Prof M G K Menon, whose thrust was on R&D development in public sector. In a way, Seshagiri combined techno-economic thinking of Sarabhai and pro-public sector standpoint of Prof Menon. This reflected in institutions he built and policies he developed for IT industry in 1980s. The National Informatics Centre (NIC) was the first major institution that Seshagiri conceived and implemented. Right from his initial days, he was fascinated with networking and its potential.


The turning point in his career came in 1981 when preparations were on for holding Asiad 82 under the leadership of Rajiv Gandhi. Rajiv wanted an automated result announcement to be developed by connecting all 18 venues located in different parts of the national capital. NIC developed this software and it worked very well. With this began a close relationship between Seshagiri and Rajiv which continued till the assassination of Rajiv. Seshagiri was in the inner circle of advisors of the Prime Minister known as his 'computer boys'. NIC got a boost and expanded nationally and electronics sector was liberalised. NIC actually pioneered the use of VSAT technology at such a large scale globally.

Against stiff resistance from within DoE and other quarters of the government as well industry (traditionally protected industrial houses were opposed to liberal imports), Seshagiri scripted two important path breaking policies – the 1984 hardware policy and the 1986 software policy. Being liberal and industry-friendly may be fashionable in the post-liberalisation era, but being so in a closed economy in 1980s was indeed brave for a technocrat. Seshagiri showed that bravery and declared that 'making money is not a sin' for industry. He also got a mandate from the Prime Minister's Office to 'break any rules' that came in the way of implementing the two policies.

While the hardware policy opened up import of components and tools for software development, the 1986 policy was truly revolutionary. It proposed software exports through satellite data links or external gateways. Seshagiri had strongly advocated this concept of trans-border trade in data services and information flow in a report he wrote for the United Nations Centre on Transnational Corporations (UNCTC) in April 1984. He included this concept in the 1986 policy. Though it took many years for small software firms to be able to use satellite data links, the policy proved to be a watershed. The Software Technology Parks (STP) scheme with satellite data links was born soon after and paved the way for development of the billion-dollar Indian IT industry in 1990s and 2000s. Seshaghiri also conceived the idea of Indian Institutes of Information Technology (IIITs) and second level of reforms in the IT Task Force set by the Vajpayee government.

Seshagiri was a true visionary and remained so till the end. I was fortunate to have remained in touch with him after he settled down in Bangalore following his retirement from NIC. Very few people know that he was constantly working with new ideas and keeping up with the latest in information technology. One of the major projects he executed after his retirement was conceiving and editing a 27-volume series of reference books on Cities and Towns of India, published by the Delhi-based Gyan Publishers in 2008. In 2012, he came out with similar series on villages of India. It was seminal work, never before attempted by any government agencies. The 27-volume series is called *Survey of Rural India: A comprehensive Study of Gram Panchayat and Community Development Block*. This is something he wanted NIC to do, but government support did not come for this. Seshagiri developed the methodology for research, collection, collation, and validation data collected from all over the country. He had even planned a system for constant updating of the two series, and also a digital version of it in future.

In his demise, we have lost an excellent scientist, technologist, institution builder, futurologist and an able science administrator. The Indian IT industry, in particular, should be indebted to this great man who laid the foundation of a robust $100 billion industry.

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# Ovarian Cancer

## Ways to Win Over the Disease

**Dr Yatish Agarwal**
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*"The bravest sight in the world is to see a great man struggling against adversity."*
— Seneca De Providentia

When a diagnosis of ovarian cancer is made, it can be extremely worrisome and challenging both for you and your family. Still, the best course of action is to face the situation with self-control and play an active part in decision making.

It is natural to want to learn all you can about the disease, the stage it is in and the choices of treatment. Your doctor can help you with the best answers, take you through various tests, and discuss the best treatment options with you and your family.

Even though in each patient the clinical decision is based on the type of cancer, stage of disease, health of the patient and her coping strength, and the treating team's previous experience with similar patients and the current global treatment guidelines, it is best never to compare oneself with other patients. The truth is: No two patients can ever match exactly and neither can their results be absolutely similar. Each patient is unique, and so are you!

The best strategy is to zero on to a good treatment centre, where specialist care and treatment facilities exist; consider the logistics and treatment costs; and when you are sure, take the plunge. It never pays to dilly-dally, think of alternative unorthodox treatments, or approach charlatans who do not know what wrong they might do.

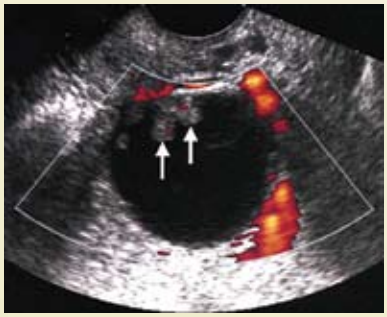
The goal post is: you must be the winner, whatever might be the hiccups.

## Identifying the stage of disease

To plan the best treatment, your doctor must know the grade of the tumour and the extent (stage) of the disease. The stage is based on whether the tumour has invaded nearby tissues, whether the cancer has spread, and if so, to what parts of the body.

The doctor may order a number of tests to find out how far the disease has spread:

### *Abdominal ultrasound*



The simplest test that a doctor can recommend to gauge the spread your disease is to ask you to go for an abdominal ultrasound. It is totally a painless test. The sonologist (a person working in the field of diagnosis using ultrasound) points high-frequency sound waves at organs inside the pelvis and abdomen through a hand-held device. The waves bounce off the organs. A computer creates a picture from the echoes. The picture may show the entire extent of the ovarian tumour, and whether it has spread into the neighbouring structures. For a better view of the ovaries, sometimes the doctor may prefer a device that needs to be inserted into the vagina (transvaginal ultrasound) to get a more exact view.

At the same examination, the sonologist can also look for spread of disease into the abdominal cavity, lymph nodes and other major organs, like the liver.

### *CT and MRI scans*

Doctors often use CT and MRI scans to obtain pictures of organs and tissues in the pelvis or abdomen. This helps them identify how far the disease has spread.

In a CT, a highly sophisticated X-ray machine linked to a computer takes cross-sectional pictures of the area of the body under scrutiny. You may receive contrast material by mouth and by injection into your arm or hand. The contrast material helps the organs or tissues show up more clearly. The tumour, its extent, the degree of spread, presence of abdominal fluid may show up on the CT scan.

A MRI scan can play a similar role. It uses a large magnet to capture the pictures of the abdominal cavity. It can visualise the degree of spread well, and for this reason, may be preferred over a CT scan in some situations.

### *Chest x-ray*

The doctor will also ask for an X-ray of the chest. This can be useful in many ways: it helps him obtain clearance from the anaesthesiologist if he is planning a surgery, helps him know if the tumour has spread to the lungs, or if it has led to fluid in the pleural cavity (the protective membranous space around each lung).

### *Barium enema x-ray*

Your doctor may order a series of x-rays of the lower intestine. You are given an enema with a barium solution. The barium outlines the intestine on the x-rays. Areas blocked by cancer may show up on the x-rays.

### *Colonoscopy*

Your doctor inserts a long, lighted tube into the rectum and colon. This exam can help tell if cancer has spread to the colon or rectum.

### *Exploratory surgery*

Sometimes, the doctor may decide upon conducting an exploratory laparoscopic surgery to stage the disease. With the aid of a sampling probe, the surgeon takes bites of tissue from the pelvis and abdomen to check if the disease has spread into any of those tissues.

## Stages of Ovarian Cancer

Based on the findings of various tests and procedures, including biopsy, the disease is categorized into the following stages:

### *Stage I*

Cancer cells are found in one or both ovaries. Cancer cells may be found on the surface of the ovaries or in fluid collected from the abdomen.


### *Stage II*

Cancer cells have spread from one or both ovaries to other tissues in the pelvis. Cancer cells are found on the fallopian tubes, the uterus, or other tissues in the pelvis. Cancer cells may be found in fluid collected from the abdomen.

### *Stage III*

Cancer cells have spread to tissues outside the pelvis or to the regional lymph nodes. Cancer cells may be found on the outside of the liver.

### *Stage IV*

Cancer cells have spread to tissues outside the abdomen and pelvis. Cancer cells may be found inside the liver, in the lungs, or in other organs.

## Treatment

If you have been newly diagnosed with ovarian cancer, your initial reaction is likely to be that of much shock and stress. Still, it doesn't help to brood over, feel melancholy, be sad or depressed, or to feel that it's all over. Simply because, the battle has just begun and if you keep your chin up and are brave enough to fight the disease and follow your doctor's advice, you may well be the eventual winner!

You and your family must gear up to take an active part in making decisions about your medical care. You should try and learn all you can about your disease and treatment choices. Your doctor and his team can guide you through this. Knowing more about ovarian cancer helps many women cope. It often helps to make a list of questions before an appointment. To help remember what your doctor says, you may take notes. You may also want to have a family member or friend with you when you talk to your doctor—to take part in the discussion, to take notes, or just to listen.

You may want to ask your doctor these questions before your treatment begins: What is the stage of my disease? Has the cancer spread from the ovaries? If so, to where? What are my treatment choices? Will I need more than one kind of treatment? What are the expected benefits of each kind of treatment? What are the risks and possible side effects of each treatment? What can we do to control side effects? Will they go away after treatment ends? What can I do to prepare for treatment? Will I need to stay in the hospital? If so, for how long? What is the treatment likely to cost? How will treatment affect my normal activities? Will treatment cause me to go through an early menopause? Will I be able to get pregnant and have children after treatment? How often should I have check-ups after treatment?

You do not need to ask all your questions at once. You will have other chances to ask your doctor for more details. Your doctor may refer you to a gynaecologic oncologist, a surgeon who specialises in treating ovarian cancer. Or you may ask for a referral. Other types of doctors who help treat women with ovarian cancer include gynaecologists, medical oncologists, and radiation oncologists. You may have a team of doctors.

## Getting a Second Opinion

Before starting treatment, you might want a second opinion about your diagnosis and treatment plan. It may take some time and effort to gather medical records and arrange to see another doctor. In most cases, a brief delay in starting treatment will not make treatment less effective. To make sure, you should discuss this delay with your doctor.

There are a number of ways to find a doctor for a second opinion. Your doctor may refer you to one or more specialists. At cancer centres, several specialists often work together as a team.

## Coping and support

Being diagnosed with ovarian cancer would put you and your family to considerable worry and anxiety. Even when a full recovery is likely, you may feel concerned about a recurrence. But no matter what your prognosis, the challenge lies in coming out a winner with all your calm. Here are some strategies and resources that may make dealing with cancer easier:

- **Know what to expect**. Find out enough about your disease so that you feel comfortable making decisions about your care.
- **Find someone to talk with**. Find a friend or family member with whom you feel comfortable discussing your feelings. Or try meeting with a formal support group for cancer survivors. It may help to talk with others who have already been through the challenges you're facing. Support groups for the families of cancer survivors also are available.
- **Let people help**. If you have friends or family who want to help, take them up on their offers and let them know what would be most useful to you. Cancer treatments can be exhausting, so if someone wants to help, accept it.
- **Set reasonable goals**. Having goals helps you feel in control and can give you a sense of purpose. But don't choose goals you can't possibly reach. For example, you may not be able to work a full workweek but you may be able to work at least half the time. In fact, many people find that continuing to work is helpful.
- **Take time for yourself**. Eating well, relaxing and getting enough rest can help combat the stress and fatigue of cancer. Also, cut back on time commitments and plan ahead for times when you may need more rest.

## Treatment Methods

Your doctor might discuss with you the treatment choices and their expected results. Most women with ovarian cancer need have surgery and chemotherapy. Rarely, radiation therapy is also used. Cancer treatment can affect cancer cells in the pelvis, in the abdomen, or throughout the body:

### *Local therapy*

Surgery and radiation therapy are local therapies. They remove or destroy ovarian cancer in the pelvis. When ovarian cancer has spread to other parts of the body, local therapy may be used to control the disease in those specific areas.

### *Intraperitoneal chemotherapy*

Chemotherapy can be given directly into the abdomen and pelvis through a thin tube. The drugs destroy or control cancer in the abdomen and pelvis.

### *Systemic chemotherapy*

When chemotherapy is taken by mouth or injected into a vein, the drugs enter the bloodstream and destroy or control cancer throughout the body.

You may want to know how treatment may change your normal activities. You and your doctor can work together to develop a treatment plan that meets your medical and personal needs.

Since cancer treatments often damage healthy cells and tissues, side effects are common. Side effects depend mainly on the type and extent of the treatment. They may not be the same for each woman, and they may change from one treatment session to the next. Before treatment starts, your doctor will explain possible side effects and suggest ways to help you manage them.

## Surgery

### *Before the surgery*

Should your doctor suggest surgery, you may want to ask your doctor these questions before making up your mind: What kind of surgery do you have in mind for me? What would be the extent of surgery? Which all tissues will be removed? Why? How soon will I know the results from the pathology report? Who will explain them to me? How will I feel after surgery? If I have pain, how will it be controlled? How long will I be in the hospital? Will I have any long-term effects because of this surgery? Will the surgery affect my sex life?

### *How's the surgery done?*

Should you be satisfied with the answers, and decide to take the surgery, here's how it will be done: The surgeon would make a long cut in the wall of the abdomen. This type of surgery is called a laparotomy. The surgeon would remove both ovaries and fallopian tubes (salpingo-oophorectomy); the uterus (hysterectomy); the omentum (the thin, fatty pad of tissue that covers the intestines); nearby lymph nodes; and samples of tissue from the pelvis and

abdomen. If the cancer has spread, the surgeon would remove as much cancer as possible. This is called "debulking" surgery.

If you have early Stage I ovarian cancer, the extent of surgery may depend on whether you want to get pregnant and have children. Some women with very early ovarian cancer may decide with their doctor to have only one ovary, one fallopian tube, and the omentum removed.

### *Recovering from the surgery*

You may be uncomfortable for the first few days after surgery. Medicine can help control your pain. Before surgery, you should discuss the plan for pain relief with your doctor. After surgery, your doctor can adjust the plan if you need more pain relief.

The time it takes to heal after surgery is different for each woman. You will spend several days in the hospital. It may be several weeks before you return to normal activities.

If you haven't gone through menopause yet, surgery may cause hot flashes, vaginal dryness, and night sweats. These symptoms are caused by the sudden loss of female hormones.

Talk with your doctor or nurse about your symptoms so that you can develop a treatment plan together. There are drugs and lifestyle changes that can help, and most symptoms go away or lessen with time.

### *Chemotherapy*

Chemotherapy uses anticancer drugs to kill cancer cells. Most women have chemotherapy for ovarian cancer after surgery. Some women have chemotherapy before surgery. Usually, more than one drug is given.

You may want to ask your doctor these questions about chemotherapy: When will treatment start? When will it end? How often will I have treatment? Which drug or drugs will I have? How do the drugs work? Do you recommend both IV and IP (intraperitoneal) chemotherapy for me? Why? What are the expected benefits of the treatment? What are the risks of the treatment? What side effects might I have? Can I prevent or treat any of these side effects? How? How much will it cost? Will my health insurance pay for all of the treatment?

## Ways of giving anticancer drugs

Drugs for ovarian cancer can be given in different ways:

### *By vein (IV)*

The drugs can be given through a thin tube inserted into a vein.

### *By vein and directly into the abdomen*

Some women get IV chemotherapy along with intraperitoneal (IP) chemotherapy. For IP chemotherapy, the drugs are given through a thin tube inserted into the abdomen.

### *By mouth*

Some drugs for ovarian cancer can be given by mouth.

Chemotherapy is given in cycles. Each treatment period is followed by a rest period. The length of the rest period and the number of cycles depend on the anticancer drugs used. You may have your treatment in a clinic, at the doctor's office, or at home. Some women may need to stay in the hospital during treatment.

### *Possible side effects of chemotherapy*

The side effects of chemotherapy depend mainly on which drugs are

given and how much. The drugs can harm normal cells that divide rapidly:

### Blood cells

These cells fight infection, help blood to clot, and carry oxygen to all parts of your body. When drugs affect your blood cells, you are more likely to get infections, bruise or bleed easily, and feel very weak and tired. Your health care team checks you for low levels of blood cells. If blood tests show low levels, your health care team can suggest medicines that can help your body make new blood cells.

### Cells in hair roots

Some drugs can cause hair loss. Your hair will grow back, but it may be somewhat different in colour and texture.

### Cells that line the digestive tract

Some drugs can cause poor appetite, nausea and vomiting, diarrhoea, or mouth and lip sores. Ask your health care team about medicines that help with these problems. Some drugs used to treat ovarian cancer can cause hearing loss, kidney damage, joint pain, and tingling or numbness in the hands or feet. Most of these side effects usually go away after treatment ends.

## Radiation Therapy

Radiation therapy (also called radiotherapy) uses high-energy rays to kill cancer cells. A large machine directs radiation at the body.

Radiation therapy is rarely used in the initial treatment of ovarian cancer, but it may be used to relieve pain and other problems caused by the disease. The treatment is given at a hospital or clinic. Each treatment takes only a few minutes.

Side effects depend mainly on the amount of radiation given and the part of your body that is treated. Radiation therapy to your abdomen and pelvis may cause nausea, vomiting, diarrhoea, or bloody stools. Also, your skin in the treated area may become red, dry, and tender. Although the side effects can be distressing, your doctor can usually treat or control them. Also, they gradually go away after treatment ends.

## Coping with other health problems

Ovarian cancer and its treatment can lead to other health problems. You may receive supportive care to prevent or control these problems and to improve your comfort and quality of life. Your treating team will do its best to help you cope with the problems that may arise.

### Pain

Your doctor or a specialist in pain control can suggest ways to relieve or reduce pain.

### Swollen abdomen

The abdomen can swell from abnormal fluid buildup, producing a condition called ascites. The swelling can be uncomfortable. Your treating team can remove the fluid whenever it builds up.

### Swollen legs

Swollen legs, caused due to lymphedema, can be rather uncomfortable. The legs are then hard to bend. You may find exercises, massages, or compression bandages helpful. Physical therapists trained to manage lymphedema can also help.

### Blocked intestine

Cancer can block the intestine. Your doctor may be able to open the blockage with surgery.

### Shortness of breath

Advanced cancer can cause fluid to collect around the lungs. The fluid can make it hard to breathe. Your treating team can remove the fluid whenever it builds up.

### Sadness

It is normal to feel sad after a diagnosis of a serious illness. Some people find it helpful to talk about their feelings.

### Nutrition

It is important for you to take care of your well-being. Taking care of yourself includes eating well and staying as active as you can. You need the right amount of calories to maintain a good weight. You also need enough protein to keep up your strength. Eating well may help you feel better and have more energy.

Sometimes, especially during or soon after treatment, you may not feel like eating. You may be uncomfortable or tired. You may find that foods do not taste as good as they used to. In addition, the side effects of treatment, such as poor appetite, nausea, vomiting, or mouth sores, can make it hard to eat well. Your doctor, or a dietician, can suggest ways to deal with these problems.

## Physical Activity

Many women find they feel better when they stay active. Walking, yoga, swimming, and other activities can keep you strong and increase your energy. Whatever physical activity you choose, be sure to talk to your doctor before you start. Also, if your activity causes you pain or other problems, be sure to let your doctor know about it.

## Follow-up Care

You will need regular check-ups after treatment for ovarian cancer. Even when there are no longer any signs of cancer, the disease may sometimes return because undetected cancer cells could remain hidden somewhere in your body.

Check-ups help ensure that any changes in your health are noted and treated if needed. Check-ups may include a pelvic exam, a CA-125 test, other blood tests, and imaging exams.

If you have any health problems between check-ups, you should contact your doctor.

## Staying Positive

Learning you have ovarian cancer can change your life and the lives of those close to you. These changes can be hard to handle. It is normal for you, your family, and your friends to have many different and sometimes confusing feelings. You may worry about caring for your family, keeping your job, or continuing daily activities. Concerns about treatments and managing side effects, hospital stays, and medical bills are also common. But the only way forward is to stay calm, think straight, be positive and look for best possible solutions.

# Recent developments in science and technology

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## Air pollution kills more than 2 million a year

Air pollution is a problem of modern civilisation that is known to affect health in general and it is considered to be one of the major environmental risks facing the world's population. But till recently the real threat that air pollution poses to human health was grossly underestimated. A new study by researchers from the University of North Carolina, USA, has shown that more than two million people may be dying around the world every year due to air pollution. This is in addition to an estimated 4,70,000 deaths each year due to increases in ozone at ground level produced by human activity. On the other hand, climate change only has a minimal effect on air pollution and rising death rates (*Environmental Research Letters*, September 2013 | doi:10.1088/1748-9326/8/3/034005).

*Haze caused by fine particulate matter suspended in air is common in big cities*

Air pollution has been steadily rising since the beginning of the industrial revolution in the middle of nineteenth century, especially after widespread use of coal and oil started. Since then human activities have significantly increased the concentrations of ozone and fine particulate matter less than 2.5 micrometre in size (also known as PM 2.5) in both urban and rural regions. Ozone is a highly reactive gas – a different form of oxygen made up of three atoms joined together. If inhaled, ozone causes severe respiratory problem including cough, throat irritation, or reduced lung function leading to discomfort in the chest when taking a deep breath. PM 2.5 in the air reduces visibility and cause the air to appear hazy when levels are elevated. These tiny air particles can penetrate deep into the lungs and cause cancer and other severe respiratory illnesses.

Most ground-level ozone that causes health concerns is formed when sunlight reacts with air pollutants, especially nitrogen oxides ($NO_x$) released into the atmosphere by human activities, especially internal combustion engines. PM 2.5 particles primarily come from car, truck, bus and off-road vehicle (e.g., construction equipment, diesel locomotive) exhausts, other operations that involve the burning of fuels such as wood, heating oil or coal, and natural sources such as forest and grass fires. Fine particles also form from the reaction of gases or droplets in the atmosphere from sources such as power plants.

Climate change can affect air pollution in many ways, but it has comparatively less impact on human health. For example, rainfall can determine when pollutants accumulate. Rising temperatures can increase the emissions of organic compounds from trees, which react in the atmosphere and form ozone and fine particulate matter, but these emissions from trees are insignificant and have little direct impact on health as do pollutants released by human activity.

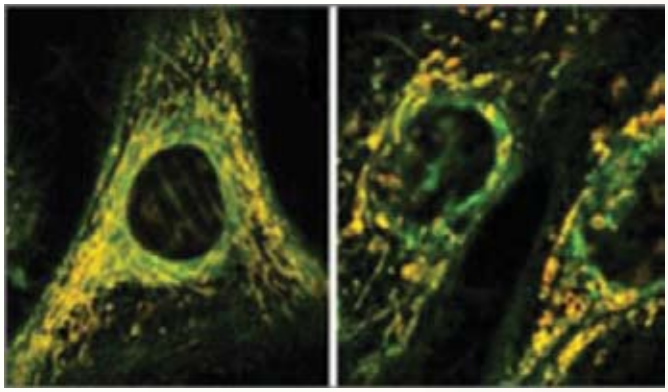
The North Carolina study was conducted through computer simulation. The researchers simulated the concentrations of ozone and fine particulate matter air pollution in 1850 – when the industrial era began – and in the year 2000. They used 14 different climate models to simulate levels of ozone and another six to simulate fine particulate matter caused by humans. In order to reach their estimate, the researchers compared the results from a range of earlier mathematical models on deaths from air pollution.

According to the study, most of these deaths due to air pollution occur in East Asia and South Asia, where population is high and air pollution is severe. India has one of the highest mortality rates due to ozone (2,08,000) and due to PM 2.5 (5,49,000) per year. This is quite alarming, yet little is being done to tackle the situation.

The major sources of PM 2.5 pollution in India include the rampant burning of fuelwood and biomass such as dried waste from livestock as the primary source of energy by the poor, and fuel adulteration, vehicular emission and traffic congestion in cities. India is the world's largest consumer of fuelwood, agricultural waste and biomass for energy purposes. Traditional fuel (fuelwood, crop residue and dung cake) dominates domestic energy use in rural India and accounts for about 90% of the total. The recent study should be an eye-opener for our planners and policy makers who should think of providing cleaner energy alternatives at affordable cost to the country's poor.

## Making long-term antibiotic use safer

It is well known that indiscriminate and prolonged use of antibiotics does more harm than good, often leading to bacteria developing resistance to even the most powerful antibiotics. Doctors often prescribe antibiotics freely, thinking that they harm bacteria while leaving human tissue unscathed. But over the years reports have piled up about the occasional side effects of various antibiotics, which can range from mild allergic reactions to severe and debilitating adverse events. Yet the mechanisms underlying these effects of antibiotics in the body remained unclear. Now a team of scientists at the Wyss Institute for Biologically Inspired Engineering at Harvard University in USA has discovered why long-term treatment with many



*Antibiotics cause oxidative stress in cells, which leads to cellular damage. For example, in healthy cells (left), mitochondria, which are labelled yellow here, are long and highly branched. But in cells treated with the antibiotic ciprofloxacin (right), mitochondria are abnormally short and unbranched, and they do not function as well. (Credit: Sameer Kalghatgi and Catherine S. Spina)*

common antibiotics can cause harmful side effects – and they have uncovered two easy strategies that could help prevent these dangerous responses.

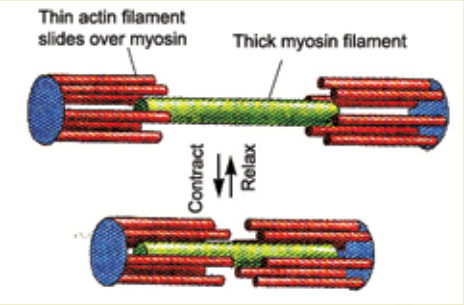
All forms of life maintain a reducing environment within their cells. This reducing environment is preserved by enzymes. Disturbances in this normal redox state can cause toxic effects through the production of peroxides and free radicals that damage all components of the cell, including proteins, lipids, and DNA. A condition known as oxidative (taking place in presence of oxygen) stress is caused by an imbalance between the production of reactive oxygen and a biological system's ability to readily detoxify the reactive intermediates or easily repair the resulting damage. In humans, oxidative stress is involved in many diseases, such as atherosclerosis, Parkinson's disease, heart failure, Alzheimer's disease, and chronic fatigue syndrome.

Reactive oxygen species can, however, be beneficial, as they are used by the immune system as a way to attack and kill disease-causing organisms. Reactive oxygen species are also used in cell signalling. Problem arises only when the production is in excess. It has been suggested that bactericidal antibiotics (antibiotics that kill bacteria) induce the formation of toxic reactive oxygen species in bacteria. The Wyss Institute team led by Jim Collins has shown that clinically relevant doses of many of the commonly used antibiotics cause mitochondrial dysfunction and overproduction of reactive oxygen species in mammalian cells. The researchers found that it is these bactericidal antibiotic-induced effects that lead to oxidative damage to DNA, proteins, and membrane lipids, and that these harmful effects of antibiotics can be relieved by antioxidants (*Science Translational Medicine*, 3 July 2013 | doi: 10.1126/scitranslmed.3006055).

The researchers treated mice with bactericidal antibiotics and found the animals exhibited elevated oxidative stress markers in the blood, oxidative tissue damage, and other symptoms which indicated the potential physiological relevance of these antibiotic effects. However, the harmful effects of bactericidal antibiotics were relieved in cell culture and in mice by the administration of the antioxidant N-acetyl-L-cysteine, or prevented by preferential use of antibiotics that did not kill bacteria but only stopped their multiplication. According to the researchers, this work highlights the role of antibiotics in the production of oxidative tissue damage in mammals and also suggests possible strategies to mitigate or prevent the resulting damage, with the goal of improving the safety of antibiotic treatment in people.

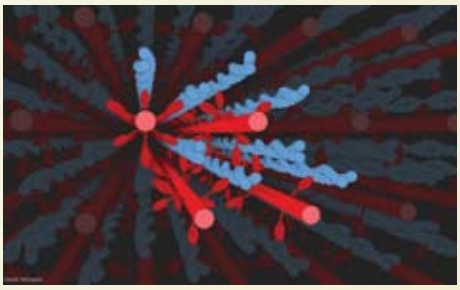
## New light on muscle contraction

Beating of the human heart and all the body movements are controlled by muscles, which work by either contracting or relaxing. Muscles are the 'engine' that our body uses to propel itself. Although they work differently than a car engine or an electric motor, muscles do the same thing – they turn energy into motion. Muscles are mainly composed of alternating rows of myosin protein filaments and actin protein filaments. When the muscle is relaxed those rows are least overlapped. When nerves called motor neurons send commands to a muscle to contract these rows overlap making the muscle shorter in length and causing a mechanical function. Muscles expand as they get shorter: biceps bulge and calves curve. Muscles also generate differing levels of force as they shorten.




*Structure of muscle (diagrammatic)*

Since the 1950s scientists have had a formula – the so-called length-tension curve – that accurately describes the force a muscle exerts. It was believed that the force a muscle can generate depends upon both the length and shortening velocity of the muscle. This theory did not consider the bulging that accompanies shortening to explain differing levels of force production as muscle changes length.



*A 3-D computer model of filaments of myosin (red) reaching out and tugging along filaments of actin (blue) during the contraction of a muscle. The model allowed researchers to consider the geometry and physics at work on the filaments when a muscle bulges (Credit: D. Williams/University of Washington)*

Now new research by a team led by scientists of the University of Washington has greatly expanded our understanding of how muscles get their power. One of the major discoveries that the new research brought to light is that force is generated in multiple directions, not just along the long axis of muscle as everyone thinks, but also in the radial direction. It shows that as muscles bulge, the filaments are drawn apart from each other, the myosin tugs at sharper angles over greater distances, and it is that action that accounts for half the change in muscle force scientists have been measuring. According to the researchers, only 50 per cent of the muscle force comes from changes as muscles shorten and myosin and actin

filaments overlap. The bulging perpendicular to the direction of a muscle's contraction alters the force muscle produces. A muscle that can bulge produces up to a 50% greater peak force than a muscle that is held flat. (*Proceedings of the Royal Society* B, 10 July 2013 | doi:10.1098/rspb.2013.0697).

The discovery was made using computer modelling to test the geometry and physics of the 50-year-old understanding of how muscles work. The computer results of the force trends were tested and validated through X-ray diffraction experiments on moth flight muscle, which is very similar to human cardiac muscle.

This study gives scientists and doctors a new basis for interpreting experiments and understanding the mechanisms that regulate muscle contraction. According to the researchers, the new understanding of muscle forces derived from this study has implications for better understanding of the use of all muscles, especially those of the heart. The new, detailed models of muscle structure and dynamics would allow the study of heart muscles at a molecular level for the first time and may throw new light on cardiac diseases.

## Neanderthal man had a language

The Neanderthals (*Homo sapiens neanderthalensis*) are an extinct species or subspecies of the genus Homo which is closely related to modern humans (*Homo sapiens sapiens*). Comparison of the DNA of Neanderthals and modern humans suggests that they diverged from a common ancestor between 350,000 and 400,000 years ago. It is not known exactly when the Neanderthals became extinct and whatever is known about them is from fossil records. Fossil records show that the brain size of Neanderthal was as large as that of modern humans, perhaps larger. Neanderthals made advanced tools, had some kind of language and lived in complex social groups. But they lost out to modern humans in the battle to survive because they were not clever enough to adapt.

Although Neanderthals were very similar to modern humans in many respects, nothing was known about whether they could speak like humans. It was usually assumed that modern language is a recent phenomenon, coinciding with the emergence of modern humans themselves.

*Artist's impression of a Neanderthal man making tools (Credit: http://ancientstandard.com/)*

But new research points to a different origin of human languages. Fast-accumulating data seem to indicate that the Neanderthals were much more similar to us than imagined even a decade ago. They may have possessed language, and their words might even have contributed to the languages of our species, two scientists propose.

Researchers Dan Dediu and Stephen C. Levinson of the Max Planck Institute for Psycholinguistics in Nijmegen, Netherlands analysed new record of human fossils and archaeological data and reassessed older data, especially ancient DNA, to infer that modern language and speech can be traced back to the last common ancestor we shared with the Neanderthals, roughly half a million years ago (*Frontiers in Psychology*, 5 July 2013 | doi: 10.3389/fpsyg.2013.00397).

According to the researchers, it is well established that Neanderthals were our closest cousins, sharing a common ancestor with us around half a million years ago – probably the species called *Homo heidelbergensis*. But it has been unclear what their mental capacities were, or why modern humans replaced them – an estimated 28,000 years ago – after thousands of years of cohabitation. We now realise that their fate was much more intertwined with ours and that, far from being slow brutes, their cognitive capacities and culture were comparable to ours, the researchers say.

The new interpretation contradicts the scenario usually assumed by most language scientists, that of a sudden and recent emergence of modern language – presumably due to one or very few genetic mutations. Instead, the present researchers favour a scenario of gradual accumulation of biological and cultural innovations.

The new findings would push back the origins of modern language over ten-fold, from the often-cited 50 or so thousand years, to around a million years ago. That is somewhere between the origins of our genus, Homo, some 1.8 million years ago, and the emergence of *Homo heidelbergensis* from which the Neanderthals and modern humans are believed to have evolved separately.This reassessment of the antiquity of modern language has profound consequences for the understanding of our own evolution in general and especially for the sciences of speech and language. ■

# National Meet on the Role of Planetaria in Science Communication

A two-day-long 'National Meet on the Role of Planetaria in Science Communication' was organised jointly by MP Council of Science and Technology (MPCST) and Vigyan Prasar, New Delhi at Vikram University Swaran Jayanti Hall, Ujjain on 10-11 June 2013. The main objective of the meet was to further the role of planetaria in science communication. The meet also offered a common platform for science communicators to interact with astronomers and directors of the planetaria from all over the country. The participants included astronomers, science communicators, directors of planetaria, researchers, and students of astronomy.

The meet was inaugurated by the chief guest Prof. D.P. Singh, Vice Chancellor, Devi Ahilya Vishwavidyalaya, Indore. He said technology plays a significant role in our daily life, but today there is a lack of interest in basic science among the youth, which he said is a serious matter. He added that the Union government has launched a unique program INSPIRE to motivate students towards science. He also emphasised that science education should be made enjoyable and fruitful for the common man. He said planetaria should organise events, conferences and seminars to popularise astronomy and related events.

In his presidential address Prof. Pramod K. Verma, Director General of MPCST said that Ujjain had a glorious past and is the second oldest city in the world after Banaras. He described Ujjain as a city of scholars that had connection with Varahamihira and Bhaskaracharya in ancient times. Prof. Verma said "Our slogan is '*Vikas ke baat, Vigyan ke saath.*'and we focus our attention for inclusive development of state". He also indicated that this event would be organised every year to promote astronomy research and interaction among astronomers and science communicators of the state. He hoped that the ultramodern planetarium of Ujjain would play a significant role of 'edutainment.'

The guest of honour Dr. B.P. Singh, Head and Scientific Adviser, NCSTC, New Delhi, talked about the need of developing scientific temper in society. Dr. R. Gopichandran, Director, Vigyan Prasar, said that scientific temper is not writing poetry.


*Inaugural session of the National Meet (from Left) Dr Arvind C Ranade, Prof. Pramod Verma, Prof. D. P. Singh, Dr R. Gopichandran and Dr Rajesh Sharma*

It is connected with our real-life activities. He also expressed his views on the changing role of planetaria in the present century and stressed on extension of planetarium activities. The inaugural function ended with vote of thanks by Incharge of Planetarium and Resource Scientist, MPCST, Dr. Rajesh Sharma. Dr. Arvind C. Ranade, Senior Scientist, Vigyan Prasar, conducted the inaugural function.

## Technical Sessions

The meet was divided into four technical sessions. The first technical session was started with a talk by Dr. N. Ratnashree, Director, Nehru Planetarium, New Delhi on 'Art and Science of Planetarium Show.' The second speaker was Dr. B.S. Shylaja of Jawaharlal Nehru Planetarium, Bangalore, who delivered a talk on 'Outreach through Planetarium.' Dr. Srikant Pathak of Nehru Science Centre, Mumbai gave a lucid description of 'Planetarium Technology.' Dr. D.P. Durai of M.P. Birla Planetarium, Kolkata described the 'Evolution of Planetaria in India.' Dr. Padmakar Parihar, Scientist, Indian Institute of Astronomy, Bangalore, chaired the session.

In the second technical session Dr. B.P. Singh and Dr. D.K. Pandey of NCSTC jointly gave presentation on the 'Role of Mobile Planetarium.' The second speaker Shri Arvind Paranjapye of Nehru Planeterium, Mumbai discussed the importance of 'Hands-on Activities in Planetarium.' The third speaker, Dr. Anand Hota of Centre for Excellence in Basic Sciences (CBS), Mumbai spoke on 'Networking Pro-Am through Planetarium.' The last speaker of this session was Dr. Aniket Sule Homi Bhabha Centre for Science Education (HBCSE), Mumbai spoke on 'Astronomy Olympiad.' This session was chaired by Dr. Arul J. Prakash of KSTM, Thiruvananthapuram.

The third technical session included four speakers. Mr. Akshat Singhal delivered a talk on 'Indigenous planetarium'. Mr. Abhijeet Shetye from Mumbai presented his views on 'Infovision, India'. Mr. N.R. Kabra from Kolkata gave a detailed presentation on 'GOTOINIC India'. Mr. Pankaj Bhambha from Delhi spoke about 'Leo Planetarium'. The session was chaired by Dr. B.P. Singh of NCSTC, New Delhi.

The fourth and last technical session on 12 June was devoted to a panel discussion on 'Good and Bad in my Planetarium.' The session was chaired by Dr. R. Gopichandran, Director, Vigyan Prasar. During the panel discussion, directors and co-ordinators of planetaria shared their rich experience and presented their views. In the end all the participants came to the conclusion that the role of plantaria need to be redefined in the changing scenario and prepare to face new challenges including communication of different disciplines of science.

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(Reported by : Chakresh Jain, Project Officer, MPCST, Nehru Nagar, Vigyan Bhawan, Bhopal. E-mail: jchakresh2002@yahoo.com)

# Vidyarthi Vigyan Manthan 2013-14

Vidyarthi Vigyan Manthan (VVM) is a national level talent search science programme for students of class 6 to class 11 through competitive examinations and workshops. Its main objective is national integration through Indian science and technology. VVM is being organised by Vijnana Bharati and supported by Vigyan Prasar.

This year VVM has a theme subject "Indian Space Science and its Achievements". The Indian Space Research Organisation (ISRO) has provided the text material on the development of space science in India and that will be the part of study material for the participants.

Students from class 6 to class 11 can participate from all over India. They shall be divided in two groups with different levels, as shown below:

**Group - A: Classes 6, 7, and 8 Group - B: Classes 9, 10, and 11**

The first- and second-level screening (State Level Screening) shall be done through written examination (objective type) for all students. Then, each state shall conduct a State Camp to identify and select participants for National Camp. Vijnana Bharati shall make stay and food arrangements for participants in the National Camp.

The gist of the text material of 'Indian Contribution to Science & Technology', which covers 40% of the total syllabus, shall be published by *Science India* – a popular science magazine in Hindi and English – in the issues of September and October 2013. The same shall be available on the website of Vigyan Prasar (www.vigyanprasar.gov.in) and Vidyarthi Vigyan Manthan (www.vvm.org.in).

Any school in the country can register for VVM online (www.vvm.org.in) or can send applications to Office of National Coordinator, 501, King Apartment, Behind Reliance Fresh, Navlakha Square, Indore (MP), India latest by 31 August 2013 by registered post. The registration fee for each school for participating in the VVM is fixed at Rs.1,000.00 (Rs. One thousand only) for 60 students or less. But they can enrol individual participants for VVM by charging Rs.50.00 as the registration fee.

For every student above the limit of 60, the school has to pay Rs.20.00 (Rs. Twenty only) per student. The remaining money, collected from the students, can be utilised for conducting *Prathama* and *Dwitiya* examinations and science club activities.

Schools can submit registration fees through DD drawn in favour of VIDYARTHI VIGYAN MANTHAN, payable at Indore (M.P.).

Details of screening, syllabus, exam pattern and dates, scheme of marking, and award and cash prizes are available on website **www.vvm.org.in**.

**Last date of registration for Vidhyarthi Vigyan Manthan 2013-14: 15th September 2013**



## Letters to editor

### Thanks for informative articles

I am a professor of physics, a science writer in Kannada, and a regular reader of Dream 2047. I regularly read the articles by Dr. Yatish Agarwal. In three recent issues (May, June and July) I read the articles on prostate enlargement. They were excellent and very informative. As I am suffering from prostate problem, the articles have given me much required confidence!

Dr. Agarwal's articles on gall stones (March and April) actually helped instil confidence in a close relative of mine for whom some tests had suggested the presence of gallstones. It has been mentioned in the article, 'if no problems - better not touch it'. My relative too has no problems and was relieved after reading the article.

Thank you for publishing such informative articles.

Dr AP Radhakrishna
http://apkrishna.wordpress.com

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### An error

In the May 2013 issue of Dream 2047, the article 'The Curious World of Numbers was very interesting. But I found some printing mistakes as described below.

On page 29, column 2, line 2 from bottom – the last figure of the line should be 1728 and not 1729.

On page 28, column 1, line 8 from bottom – the fourth figure should be 120 and not 121.

Mathematics musings basically deal with additions and subtractions. Please do not mind if I reduced two figures, each by one.

Kalyana Mohapatra
Malisahi, Cuttack,
Odhisha

**Editor's comment:** The figure 1729 on page 29 is correct; there is no printing mistake. However, on page 28, the number should have been 120, as rightly pointed by Shri Mohapatra. We regret the error.