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From scientific literacy to scientific research: the Indian experience

At the outset let me dissociate this lecture from any feeling you may have that this is one more in the umpteen exercises currently going on reviewing the millennium. For two valid reasons. First, if we repose any faith in our counting system, the second millennium A.D. does not end till the last day of the year two thousand. As such all celebrations, reviews and forecasts reserved for the end of a millennium and for welcoming the new one, are one year too soon, if they are being carried out now. The second reason is that this is a highly personalized account of how I have worked in the field of science. So I hope that you will take it for what it is instead of an objective view.

India is a land of contrasts. Taking this statement beyond the cliché stage, the title of my talk is designed to highlight the peaceful coexistence in this country of high quality international level research in science and total illiteracy about what science stands for or about the basic scientific facts about nature. While the one hand our achievements in space technology have generated a confidence that India can launch a spacecraft to the moon, on the other hand, there are people who include the moon amongst the planets. Our scientists have managed to extract energy from the deep interiors of atomic nuclei, but at the same time large populations can be fooled by simple chemistry experiments into thinking that their perpetrator is performing miracles. We produce software comparable to the best in the world, but in the minds of many people its use is linked to computerized horoscopes.

I will return to these contrasts towards the end of this talk, where I will stress the fact that the peaceful coexistence of the two contrasts spells danger for society. These two ends - scientific research and scientific literacy, have engaged my mind throughout my life. I will begin this autobiographical survey from my early student days.

Salad days

My school and undergraduate college days were spent in the pleasant campus of the Banaras Hindu University, during what I recall as the golden age of that institution, when luminaries like Dr. Radhakrishnan and Acharya Narendra Dev were at the helm as vice chancellors. My father, at the time, was professor of mathematics and it was through his personal example that I was initially attracted towards science - especially towards mathematics. Mathematics is the queen of

sciences, yet mathematics is an art. Both these apparently contradictory statements carry conviction when one observes mathematics in action in its various manifestations. Unfortunately, our school education presents mathematics in neither of these forms. Rather, it is given as a set of rules to be presented in a wrong light. That mathematics is an art with aesthetics that can be enjoyed just like a good painting or a musical piece is never brought to the attention of the student. Nor is the student shown how quantitative statements subject to mathematical manipulations really lend credibility to science. The exercise in scientific illiteracy begins right here in our school science classes. Students are encouraged to learn the subject through memorizing the rules and results rather than as an adventure of discovering the laws of nature.

Fortunately for me, the adventure route was available. Mathematics has numerous recreational aspects in the form of games, puzzles and game-teasers, paradoxes and fallacies, through which a student can appreciate its splendour. When one has the opportunity of broadening one's vista this way, equations, fractions, surds and integrals take on a friendly form.

One lucky circumstance for me was that my maternal uncle Morumama (the late Professor M.S. Huzurbazar, who retired as Director of the Institute of Science, Mumbai) came to live in our house as a student of the M.Sc. course in mathematics. It so happened that our house in the B.H.U. campus had two wall-blackboards put in by my father to encourage me and my younger brother to write or draw, as it pleased our fancy. Morumama found another use for those boards: to write mathematical brainteasers for me to solve. He would write one and

place a title on the top: Challenge Problem for JVN. Then it was for me to solve the problem, thereby either meeting the challenge successfully, or giving up. Till either outcome, the problem would remain on the board.

In retrospect, I now find that this experience was extremely valuable to me in my later career as a scientist. The challenge of an unsolved problem must excite the scientist, if he or she has any hope of solving it. If it is perceived as a routine problem like that handled by a bureaucrat, such as asking for a ruling in a given situation as per government regulations, then the scientist ceases to be a scientist. Again, I will come back to this aspect while reviewing the current scenario.

When I went to Cambridge to do the Mathematical Tripos, the attitude of facing up to challenges stood me in good stead. Unlike the college teaching I had till then experienced in India, there was no spoon-feeding at Cambridge. A course would be completed in 24 lectures, covering material that would normally be covered in an Indian university in twice or thrice as many lectures. In the examinations you faced new questions, not drawn out of the lot of the past five-year's questions. For, originality of questions was a challenge to the examiner too. The examiner's mettle was also tested through the kind of questions he set.

In this connection I can share with you two Tripos stories. The first one concerns two Cambridge dons, one from mathematics and the other from economics. The mathematician said to the economist: 'In the Mathematical Tripos examination we take care to set new questions every year, which is why it is considered very difficult for the students. In your Tripos, I find that the same questions

are repeated almost every year. 'That must make it very easy for your students.' 'Quite on the contrary!' replied the economist. 'Our questions may be the same but the answers differ every year. So it is not as easy as you think.'

The second anecdote is an apocryphal story about two undergraduates of the last century, Thomson and Parkinson. In those days, successful candidates were ranked as Senior Wrangler, second Wrangler, third Wrangler, and so on. The Senior Wrangler being the topper in the examination, commanded great respect and there was keen competition for the first rank. Both Thomson and Parkinson were very good scholars and it was generally believed that one of them would be the Senior Wrangler. After the results were announced, Parkinson was declared the Senior Wrangler and Thomson the second. The examiner of one paper had a serious doubt, however. A question he had set was extremely difficult and had been correctly solved only by these two. Both examinees had used the same steps towards the solution, and this led him to wonder if one had copied the other. So he summoned the two, one after the other, to investigate the matter. "Tell me how you managed to solve this difficult problem?" he demanded to know of Parkinson. "Sir, I read research papers, and I found that this problem had been discussed and solved in one such paper" replied the student. The examiner was impressed with this answer, as he had indeed picked up that question from an anonymous research paper and he complimented Parkinson for reading research papers while still an undergraduate. Then he called Thomson, convinced that he must have copied Parkinson. Sounding annoyed, he told Thomson: "I see you have solved this question, which was taken by me from a research paper. Would you care

to tell me how you did it?" Replied Thomson, "Sir, I wrote that paper". This second anecdote conveys the heights that can be scaled by stalwart scientists when they set high goals. Thomson went on to become famous as Lord Kelvin, making seminal contributions to the areas of thermodynamics and electrodynamics.

The Cambridge policy of 'swim or sink' can either prove to be a graveyard for the unprepared student or an elevating experience for the genius. One of my fellow students at the Mathematical Tripos was Brian Josephson, who by then had demonstrated his knack for solving difficult problems in pure mathematics. It came as a surprise to many of us, when he opted to do research in physics. His research on what became known as the Josephson junctions later fetched him a Nobel Prize.

A career in research

It was during my Tripos days that I happened to pick up a copy of Fred Hoyle's book *The Frontiers of Astronomy* from the local public library. That book and later Hoyle's lectures were the motivating agents for my taking up a career in astronomy. Apart from Hoyle's informal and engaging style of writing and speaking, the contents of the book as well as the lectures themselves were very thought provoking. With my liking for mathematics, it was a revelation to see how the mystery behind the vast and distant objects of the cosmos could be unravelled with the application of the known laws of physics formulated in mathematical language. Fortunately, my performance at the Tripos was sufficiently good for me to get a scholarship to continue my studies in Cambridge and more importantly to have the supervisor of my choice.

My first encounter with Hoyle is still fresh in my mind. It was on a sunny June morning in the year 1960 that I walked up to his house for a first briefing on how I should embark on a research problem. Hoyle discussed several problems, but I noticed he left out any mention of steady state cosmology, a theory of which he was a co-originator with Hermann Bondi and Tommy Gold. When he had finished I asked, "But, what about the steady state theory? Can I not work on that?" His reply was very revealing. "Sure, there are many interesting topics in that theory to work on, but I do not want you to be disappointed, like a child being told that you cannot have that attractive looking ice cream, as it is bad for your health." I came away that day with another problem - to find a problem to solve that was not controversial.

Let me elaborate on this point a little, as it will form an important part of my talk. The subject of cosmology deals with the questions of the origin and large-scale structure of the universe. After the 1929 discovery by Edwin Hubble that the universe is expanding, scientists had been busy making mathematical models to describe the phenomenon. The most popular models were based on the general theory of relativity, formulated by Einstein in 1915. These models led one to the inevitable conclusion that the universe originated in a gigantic primeval explosion, which Hoyle dubbed the 'big bang'. The notion of a big bang was (and still is) mathematically ill-defined, and represented an instant when all laws of physics broke down. Nevertheless, if we identify this singular event with the origin of the universe, it leads to further questions. For example, how was matter and radiation suddenly created in violation of the laws of conservation of matter and energy? And if the time span is counted from that instant to the present, why does it fall below the

ages of some of the old stars we find in our galaxy? Such questions had prompted some physicists to look for alternative interpretations. In 1948, the steady state theory was born out of such attempts.

The steady state theory envisages an ongoing universe that has no beginning and no end, in which the physical conditions on the large scale are unchanging. The word 'steady' denotes this feature; it does not necessarily imply a static universe. A river in which water is flowing steadily presents an unchanging appearance. Likewise, one can envisage an expanding universe that is steady. To preserve a constant density of matter and radiation despite expansion of the volume, new matter and energy have to be created. Was this not a violation of the law of conservation of matter and energy? To get round this problem, Bondi and Gold had started their formulation with a general principle called the Perfect Cosmological Principle, which guaranteed this state of the universe. Hoyle on the other hand believed that a steady state could be maintained without violation of conservation laws, simply by introducing a new source field, which has negative energy and negative stresses. He had accordingly modified Einstein's equations to include this new field.

Although the philosophical approach of Bondi and Gold had its own attractions, I felt more attracted to Hoyle's approach which was grounded in physics and had hoped to work out details. Hence I was disappointed that he did not encourage me to work on this theory so that I was not drawn into controversies. On that June morning I came away with some other research problem to investigate. However, little did I realize that there was a different scenario in store for my research!

By the end of December that year, I had worked out the problem that Hoyle had given me to the extent that it could be solved. And so I was back at his doorstep with demands for more. As luck would have it, the Ryle-Hoyle controversy broke out just then, an event that set me willy nilly on track of the steady state theory. It was also my first experience of how deep and personalized such controversies can be and of how other considerations can enter into what should otherwise remain an objective scientific debate.

Martin Ryle, the leading radio astronomer at Cambridge had been observing the distribution of cosmic sources of radio emission out to great distances. As the astronomer observes a remote source, he sees it as it was in the past when the radiation (reaching the observer today) left the source. Ryle's purpose was to explore whether the density of the sources remains the same at great distances (as expected by the steady state theory) or whether the density rises with distance (as expected in the big bang theory). Ryle claimed that his data disproved the steady state theory.

Perhaps it is because cosmology deals with a very profound question about the origin of the universe that it gets mixed up with philosophical issues where cultural upbringing can play a subtle role in influencing the scientist. Thus, for example, I noticed that scientists of religious persuasions contending that the creation of the universe occurred as a one time event, seemingly feel comfortable with the idea of the big bang. At one meeting of the International Astronomical Union, held in Rome, even the Pope accorded the idea his moral and spiritual support. To such scientists, the idea of a universe without a beginning is hard to visualize. Perhaps, the more

pragmatic Hindu philosophy with its many different interpretations of the nature of the universe can be accommodative of an idea like the steady state theory as well as of the big bang.

Fred Hoyle believed that there was sufficient latitude in the way Ryle was interpreting his data to, in fact, accommodate the steady state theory. He asked me to collaborate with him in demonstrating through a mathematical model that this is indeed the case. I was thus drawn into the Hoyle-Ryle controversy. However, it so transpired that Hoyle had a lecturing commitment on the very day on which Ryle was to present his results to the august gathering of the Royal Astronomical Society in London. So Hoyle asked me to present our joint reply to Ryle's work. Contrary to his early resolve to shield a research scholar from controversies, here I was, a raw student of hardly six months experience, being asked to counter an important attack by a seasoned opponent.

In the end it went off smoothly and I learnt a lot from the experience. In particular, I discovered that if you have confidence in your work, backed by figures, then you can take on any adversary in a scientific controversy. I also discovered through the non-academic arguments used in criticizing the steady state theory, how deep-rooted personal and cultural convictions can supplant objective criticism.

My research philosophy

I have dwelt on this first experience in somewhat detail because it shaped my future career. In all my scientific work, I have generally tended to be nonconformist, especially where I find that an objective

assessment of evidence does not warrant an entrenched belief, no matter how popular it may be. It is somewhat ironical that many of the statements that Hoyle and I were making in the context of the steady state theory in the 1960s, while then considered outlandish, have now become assimilated in mainstream thinking after suitable adaptation in the big bang scenario. These include, for example, the concept of a scalar field with negative stresses, the notion that the commonly known particles - the baryons - need not be conserved, the existence of homogeneity on the scale of super clusters and voids in the universe, the possible existence of a massive black hole like object in the nucleus of a typical galaxy, etc.

This attitude of mine was inspired by Fred Hoyle, who is perhaps the greatest idea generator in astrophysics that I have come across. He has stated that in science what stimulate him are anomalies, where the existing paradigm apparently fails. Whereas the typical researcher in the field would hold on to the paradigm, trying to twist and modify it slightly to accommodate the anomalies, Hoyle preferred to think afresh along entirely different lines. He argues that if with so much conformist brain-power working along conventional lines the data cannot be explained, then it is a signal from nature that a new approach is needed.

Science has progressed in two ways; one via enlarging the existing paradigm, by making it more profound and enlarging its scope. The other is through unexpected discoveries or totally new ideas that come as major or minor revolutions. Astronomy has, on the one hand, expanded along conventional lines, drawing upon the progress of physical theories and taking advantage of new technologies to observe more of the universe. But on

the other hand, it has had its share of such revolutions that were totally unexpected. On observational fronts, the expanding universe, quasars, pulsars, etc. are examples of unexpected findings. On the theoretical front, the ideas on the origin of elements in stars and the role of strong gravitational fields near black hole like objects are examples of bold applications of physics to new scenarios.

However, the scientific community is by and large cautious, and likes to tread warily along the tried and trusted route. Recognition for unconventional work is hard to come by or come very late. Recall that Einstein did not get a Nobel Prize for either the special or the general theory of relativity. Recall too that Subrahmanyan Chandrasekhar got his Nobel Prize at the age of seventy three, for work done fifty years earlier. Revolutionary ideas or findings are treated with scepticism, largely because there is no end of cranks in the world!

While this has been the tradition in the past, recent trends are somewhat more disturbing. Because there is now big money at stake, research no longer comes cheap. When peer review committees take decisions on projects submitted for financial support, they usually go for safe ones. Safe means conventional, following tried and trusted lines. Such reviewers are often very critical with proposals that do not toe the line. For example, a very reputed scientist in the U.S. submitted a proposal that questioned an existing paradigm. Among other items, the proposal asked for a grant for a post-doc. One reviewer remarked: "This is a dodgy area, in which no young person should be allowed to work". While another wrote: "This cannot be a fruitful area to investigate as no young persons are working in it". Heads you win, tails I lose!

This reminds me of a joke about God applying for a grant from the National Science Foundation to do further work on creation. The peer reviewer turned down the application because (a) the applicant had not worked in the field for a long time, (b) nobody had been able to repeat his first experiment and (c) his work had not been published in a refereed book!

Apart from the difficulty of getting project grants, there is the difficulty of getting your paper published in a reputed journal, because the mindset of a typical referee is to reject anything that does not conform. I have repeatedly faced this difficulty and can therefore speak from first hand experience.

Finally, I should narrate the case of a distinguished observational astronomer who began to find several anomalies in the evidence that leads to the hypothesis of an expanding universe. Naturally his arguments were treated with scepticism and ridicule. Later he was denied observing time on good telescopes, essentially on the grounds that what he kept on finding did not seem to make sense. Evidently, the powers that be decided that anything that did not fit into the accepted paradigm did not deserve attention! The history of science, on the other hand has shown umpteen examples where anomalies have led to a new and better understanding of nature.

A new cosmology

In 1964, Hoyle and I proposed a new theory of gravitation, which was inspired by Mach's principle. In the 1890s, Ernst Mach a philosopher-physicist and one time mentor of Albert Einstein had proposed the notion that what we call inertia of matter, which gives it its mass,

is not just its intrinsic property, but is linked with the large scale distribution of matter in the universe. There are attractive arguments leading to this notion, which I will not dwell upon here. These were arguments compelling enough to make Einstein think of incorporating them into his theory of gravity, the general theory of relativity. Einstein did not succeed in this enterprise, however, and later in his life lost interest in Mach's principle. Others like Dennis Sciama, Carl Brans and Robert Dicke have proposed gravity theories originating from Mach's principle. Ours was one such attempt. Later I was able to extend this theory to include the kind of anomalous phenomena that I described earlier; anomalies that were difficult to reconcile within the expanding universe models based on the conventional gravity theory of Einstein. In 1993, Fred Hoyle, Geoffrey Burbidge and I used the theory to arrive at a new cosmological theory that combines some aspects of the rival steady state cosmology and the big bang cosmology. Called the Quasi-Steady State Cosmology, this theory describes the universe as an ever-existing system in which new matter is created through mini-explosions, and in which the universe expands on a long time scale of around a thousand billion years superposed with short term oscillations of 40-50 billion years period. As mentioned earlier, such new ideas have to surmount the general credibility-cum-hostility barrier, to be taken seriously. But if you have chosen to be a non-conformist, you need endless reserves of patience!

Indian science

Fortunately, the Indian scientific scene is not so conservative as to discourage non-conformism to the extent it is in the West. It is still possible to make proposals, which seek to explore and concentrate on

anomalies with an established paradigm. I hope that this pragmatism will ultimately deliver some new results that are missed out in the West.

While mentioning this as the strength of Indian science, let me now stress what I believe is its major weakness. This lies in bureaucratizing science. Look at any autonomous research institution of the Government of India. It adopts grades that closely parallel the grades in the Indian administrative service. This parallelism arose presumably from the desire of the scientists to have nothing inferior to that available to the administrators and vice versa. However, it ignores the difference between the evolution of a scientist and the evolution of an administrator. The latter matures with experience acquired with age and can be trusted with greater responsibilities. The scientist, on the other hand is most productive research wise in the first decade (25-35) after the beginning of post-doctoral research. Later he slows down and becomes less effective as a pure researcher, but gets involved with other interests peripheral to science. The career advancement of a scientist, therefore, should be more directly linked to his or her performance, rather than to age or duration in a certain grade. There are objective criteria for evaluating the performance of a scientist and these need to be directly linked to how fast, or slow, his career advance is.

One reason why the number of good young scientists is declining is because of the lack of avenues for rapid advance of the meritorious ones. If A and B are in the same grade, but A is more productive than B, can A be promoted faster? If A wins several international recognitions for his work, whereas B continues in his mediocre way, is there a mechanism for the rapid rise of

A? No - the rules do not allow this! So A gets frustrated and may leave the country to go elsewhere, where his merit is recognized and rewarded while the institution is left with B.

There is another reason for the growing shortage of good research scientists and it dates back to the early years of Independence, when Prime Minister Jawaharlal Nehru's instituted the setting up of several national research institutes and laboratories. These institutions were given good facilities and relative freedom from bureaucratic procedures. Their scientists were free from teaching duties so that they could do their research freely. The intention behind the step was salutary. But in retrospect it appears misguided. I give an example from Cambridge to illustrate my point. In the mid-1960s, when Fred Hoyle was planning to set up a research institute for astronomy in Cambridge, the University convened a debate of academics to discuss the pros and cons of the proposal. One of the opponents of the scheme stipulated that the institute may be set up as proposed, but its staff members should not teach the Mathematical Tripos students. As I was a young researcher at the time, expecting to join the proposed institute, I was quite happy with this condition as it guaranteed a teaching-free research career. But Fred Hoyle thought otherwise. According to him, this was a dangerous requirement. Only by teaching students could one persuade them to join you for research. If we did not teach, we would lose this source of research students and in the long run, our institute would face a shortage of young scientists.

This is exactly what has happened in India. Whereas research institutions were created with good facilities, research in universities was allowed to decay. As

a result, university students were never exposed to exciting research being done on their campuses and they had no contacts with national institutions even if they were located in their own city. Thus, among the student population, the motivation for choosing a scientific career has steadily gone down. The unfortunate outcome of this is that national institutions are now facing an acute shortage of good research students and post-docs. If this trend continues, India's one-time boast of having the world's third largest scientific manpower will become unsustainable in terms of quality. In fact, it already has become so. One way of reversing the trend is to apply the wisdom of hindsight and try to establish bridges between national institutions and the universities, wherein researchers in the former conduct some lecture courses for university students and open their facilities to university faculty and students.

Scientific literacy

Now I come to my other interest, namely, science popularization. Before Independence, Jawaharlal Nehru had voiced the hope that after the nation had become independent and self-governing, its people would extricate themselves from the bonds of superstition and acquire what he called a scientific temper. This has obviously not happened. What is even more disturbing is the fact that the grip of superstition is strong even among the educated classes, those occupying the higher strata of society and those who control the political developments in this country. Thus it is not a symptom of a simple lack of education. Like our caste system, it goes deep into the human psyche and is, therefore, that much harder to eradicate. Nevertheless, large-scale efforts have to be made to translate Nehru's dreams into reality.

At one end of the spectrum, science popularization will help in making the masses scientifically literate. I had made a modest beginning in this direction in the U.K. through public lectures and articles in popular science magazines. One experience that I cannot forget, relates to the Friday Evening Discourse I gave at the Royal Institution in London in 1971. This venerable institution has been in the field of science popularization for a long time. I had occasion to read some of these lectures and they indeed set very high standards of lucidity and informality. It is said that these lectures were so popular that Albemarle Street, on which the Institution is located, had to be made a one-way street to cope with the traffic of hansom cabs; and this was the first one-way street ever. At the Friday Evening Discourse, the speaker is not introduced in the beginning or thanked in the end. He is conducted to the auditorium precisely at 9 p.m. at which hour he begins talking. What is more exacting is that he must end precisely at 10 p.m.! The audience can ask questions of the speaker informally during the reception that follows. I am told that one speaker got so nervous when told of the time constraints that the Director had to lock him in a room till the lecture, to prevent his running away!

But these traditions apart, the Royal Institution has set an example worthy of emulation. At IUCAA in Pune, we have been regularly organizing lecture demonstrations for school children every second and fourth Saturday of the month. This exercise has proved extremely successful and popular. In addition, during the summer holidays, some Pune school children spend a week at IUCAA doing a project with some faculty member. They visit IUCAA as they would their school and at the end of the period, write a report and give a short seminar on their work. Having

participated in this exercise for several years now, I find the experience very rewarding.

Lecturing to public audiences on the recent developments in science can also be rewarding. As I discovered by speaking Marathi or Hindi, as the case may be, the talk goes down better if it is in the mother tongue of the audience. In one mofussil town in Maharashtra I once had an audience estimated at ten thousand. Thus there is a great desire to know more about what is happening in science. I feel that scientists have a role to play in increasing public awareness about science through various public outreach programmes. Since most scientific institutions are being supported by public funds, this is the least that a scientist can do by way of paying back.

At the other end of the spectrum there are several NGOs whose efforts are concentrated on eradication of superstition. The Andhashraddha Nirmulan Samiti in Satara, in Maharashtra, for example, educates the masses on various superstitions like animal slaughter in the name of sacrifice, beliefs in ghosts and haunted rooms, psychological trance-like afflictions such as Bhanumati, the unproven claims of Vastushastra which require you to construct your dwelling in some specific format defying all architectural norms and commonsense, etc.

As an astronomer I am frequently asked whether astrology is scientific. When the norms of science are applied, the answer is a firm NO. Perhaps it is not so commonly known, but the claims and predictions of astrology have been frequently tested by scientists by applying the criteria of a scientific theory and have always been found wanting. Yet in our society many marriages are arranged by matching horoscopes, ministries are

formed by consulting experts on auspicious times and eclipses are feared as dangerous events.

An event indelibly etched in my memory took place in February 1980, when the streets of Bombay city, which prides itself on being most modern and a trendsetter in India (with all due deference to Delhi), wore a deserted look at the time of the solar eclipse. Not even during a general strike have the streets been so empty! The spectacle was repeated during the solar eclipse of 1995, although I am told that during the 1999 eclipse more people ventured out on the streets.

Surely there is something grossly wrong with our education system if well-educated adults choose to behave this way. Is the stranglehold of traditional beliefs so powerful that no injection of factual knowledge is able to wipe out the misinformation stored in our brains? Recall the story of Ganapati drinking milk. Recall how an entire village was evacuated for fear of catastrophe supposedly brought about by a planetary alignment. Recall how seriously we took the claim of producing petrol from leaves. One wonders if this is the same country that launches satellites, can send guided missiles to their distant targets, can harness atomic energy, and can produce an agricultural revolution.

Concluding remarks

I wish to leave you with these disturbing thoughts. In the year 2001 we get into the twenty first century. Whether it is the turn of the millennium or not is beside the point. In a world that is rapidly changing with time because of the science and technology revolution, we cannot afford to hold on to outdated concepts. Our very

survival demands that we extricate our head from the sand of superstitions and learn to face the facts.