Evolution and the Mind

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Iam deeply conscious that I am by no means an expert on the topic—mind. In fact, mind is one of those subjects in which each one of us is equally expert. It is characteristically a human trait, so to say, to think about thinking. We do this all the time. In that sense, mind is a very private entity to all of us and we claim very often that we know our minds.

There are indeed people who study the mind from outside, as it were. My only justification for trying to delve into this topic is that I am a student of evolutionary biology. In all these years that I have been studying 'evolution', it is the extraordinary power of the theory of Natural Selection we first learnt from Darwin and A. R. Wallace which has swayed me.

As it happens, this is a year of many anniversaries—Swami Ranganathananda's birth centenary, the 150th anniversary of the publication of the Origin of Species—Darwin's famous book. It is also the 150th birth anniversary year of one of the greatest bio-physicists that India has produced, Jagadish Chandra Bose.

It is certainly not my intention to try and get across a set of results or facts bearing on the evolution of mind. I have no such facts and I believe there are no such facts. I would rather present an impressionistic account of how a student of biology in the year 2008 might look at the problem of mind from the viewpoint of evolution. Now, why from the viewpoint of evolution? The reason is very simple. Thanks to Darwin and Wallace and the enormous progress in the biology in the past 150 years, we now know that there is absolutely no issue concerning the living world about which evolution has nothing to say. Nothing falls outside the purview of evolution. This may sound a bit exaggeration, nevertheless, it is a statement shared generally by most people who have studied biology. Indeed, a distinguished student of evolution says that nothing in biology makes sense except in the light of evolution. Given that, and what we think of conventionally as the mind as the attribute of the human being, there has to be something useful that evolution has to say about mind. So I begin with some elementary concepts.

Evolution is the common word used for a certain process of change in the forms of life which had occurred on earth. We can trace the period in which this change had occurred with the help of reasonably accurate methods of dating. According to the best estimate, it was 4500 millions of years ago that life had originated on earth. By biological evolution we refer to the process of change in the life-form that had occurred during all these millions of years. These changes have been sequential—not that one set of creatures appeared at a certain period of time, another set at another period and so on.

How do we study this phenomena? As in all scientific activities, we do this by means of observation and, to some extent, experimentation. Experimental study of evolution began about a hundred years ago. We can carry out an experiment in the present which has a bearing on the past, for one cannot experiment with the past! Then there are a whole variety of technical subjects which evolutionary biologists make use of, technical field of expertise which often go by different names—geology (the study of earth surface), Palaeontology (the study of fossils), morphology (the study of the form and structure of animals and plants), embryology (the scientific study of the development of embryos). There are also now the so-called modern areas of study such as molecular biology, biochemistry, mathematics, etc. Mathematics today has permeated all the branches of science including evolutionary biology. Finally, ecology, still an infant but complex science, which is a study of organisms and their environment in a natural seting.

Two points

There are two points which I would like to mention. The first point is that essentially all studies of evolution have to do with the external world, ie looking at the outside world. If you are doing the study, you are not looking at yourself, you are not looking inward, you are looking outward. Human evolution as a quantitative study is relatively recent. There is one feature of evolution which it shares with the study of language which again originated in Calcutta, at least its modern study—thanks to William Jones. This is called the comparative method. There are many useful and interesting things that one can say about the evolution of one particular lineage, or one particular species, by looking at it not in isolation but by looking at it in the context of many other species, some of which may be similar, while some may be dissimilar. This is something totally different from the point of view of a physicist or a chemist whose object of study is usually an isolated system, considered by itself and in itself. In fact, a physicist takes great pains to do an experiment. Imagine Galili Galileo's experiments with the pendulum, Newton's experiments with falling objects and so forth.

So there are two features of evolution in addition to the technical aspects. One is the comparative method and the other is the observation method.

Most of the serious students engaged in the study of the mind will advise us not to try to define and criticize mind. They do so for good reason. Experience has shown us in science that quite often advances can he made by asking questions and getting on with a job and being proficient in giving precise definitions. This has been true of physical science, chemical science and biology. The modern science of biology, in other words, the quantitative reductionist science of biology, to begin with J.G Mendel's discovery in 1860, all of the subsequent progress had to do with the notion of the gene and what is known as genetics. For close to one hundred years, genetics made enormous progress even though none knew what a gene was. In fact, one had to wait till 1953 when the epoch-making discovery by James Dewey, Watson and F. H. Compton Crick enabled us to see what the material nature of gene was. But even in the absence of that knowledge there had been a great deal of progress. So people, who deal with mind, say that it has to do with memory, consciousness, perception, thoughts, emotions and so on. Some of these might be pinned down by observation and experimentation while others might not be. Consciousness, for example, is a notoriously slippery feature. But the pragmatic approach says that if you have a rough idea about what is it that interests you, please make use of these words as useful constructs, both for yourself and for communicating with others, and get on with the job. So this a very pragmatic sort of approach.

The tools that one uses in the study of the mind are mainly observations and experiments. Here one must say that experiments almost always had to do with the animals. It is next to impossible to think of human experimentation. In modern days, with the advent of the so-called non-invasive experiments, there is some human experimentation going on as well. If you look into the human being, you look into the human mind, so to speak.

Then there is behaviour and neurobio-logy where mathematics comes in again. Computational science is a new science which is used in the study of the mind. Most importantly, there is one aspect to studies of the mind which is missing really from almost any other scientific study and, in fact, is kept out as much as possible is introspection. So there is probably a great deal to learn about the mind by looking within. However, one must remember that whatever insights one gets by looking within have to match up, so to say, with the usual kinds of scientific criteria of predictions, observations and so forth. So introspection cannot be the end-point but it is a very useful, valuable tool in the study of the mind because that is something you can apply to yourself, as you, a human being, might have the right amount of vigour, training and discipline. So much for consciousness.

Evolutionary change

Evolution is a process of change. We have already said so. But how does this change take place? Broadly speaking, there are three roots that we know today for evolutionary change to take place. One is called natural selection. This is a big contribution of Darwin and Wallace. The second is called drift. Drift seems to occur, first of all, at the molecular level, which means that much of the change that takes place in our DNA seems to be on account of a process similar to drift which is not due to natural selection. The third process is not so much a process of evolutionary change, as a process of change per se. It is something which results in coming into contact with something else. Today physicists call it by the term 'self-organization'. Broadly speaking, it says that if there are incipient structures in an entity those structures may be realised under certain circumstances.

Physicists had known this sort of thing for many years as 'phase transition'. I give you a very rough analogy. If you take water and keep cooling under certain conditions at a critical pressure and temperature, it turns into ice. It loses its character entirely and what was fluid and structureless, capable of flowing, now becomes a crystalline material with extraordinarily precise, reproducable and repeatable properties. So it is that kind of phenomenon when we refer to the term 'self-organization'.

Now the question is: What can evolve? Well, anything can evolve that satisfies a set of requirements—physical traits, shape, form, morphology, our ability to digest certain kinds of food, our ability to see colours, our ability to hear certain kinds of sounds and not others. In short, Our entire sensory motor ability.

The general belief in biology today is that life is essentially a property of matter. It is of course more strange kind of matter compared to tables and chairs. Thus humans have also evolved. Properties of human beings therefore have also evolved. As far as physical properties go, no one even gives a second thought to the issue. It is taken for granted. But when it comes to mental traits, we question the nature of evolution of these traits.

So what is it that natural selection requires? Three criteria are given. They are enunciated by Darwin even though he did not know how two of them actually worked. Philosophers sometime talked of problems of ontology and epistemology. The pragmatic scientific point of view, however, is to push ontology into the background and not to be bothered by definitions, questions of existence, reality, and so on. Rather it seeks to get along with more analytical problems of how do we acquire knowledge and what does that knowledge consist of.

Natural selection needs three things. One is variation of individuals. So all the members of the species are not alike; they differ from each other. That variation in some sense has to be random. Then, hereditability, which is the ability of children to resemble their parents. And finally, survival of the fittest. This last term unfortunately had become a popular phrase, and that was due to Herbert Spencer who was a philosopher.

I say 'unfortunate' because the phrase can be misconstrued in many ways. The biologists, however, refer to it to mean the differences in reproductive success. That is to say, some individuals on average leave behind more children than others. The reason they do so is because they vary in certain traits which give rise to this difference in reproductive success. The outcome of the process of natural selection is a form of evolution that amazingly enough appears to be directed with a purpose. So it seems that as if Nature in guiding evolution by natural selection has had a goal. For example, one makes statements like—fishes are designed to live in water, birds are designed to fly in the air, our hands are designed to grasp objects. So it appears that the properties of living beings are adaptive to fit certain purpose.

The most common explanation for design in Nature is that a human being, an artisan or a craftsman gives rise to this kind of design. But the biological explanation of this kind of design is that it came through the process of natural selection, a process involving nothing other than the standard rules of physics and chemistry and organization. Richard Dawkins has popularised this aspect of evolution in his book The Blind Watchmaker. What he is referring to here is that living creatures are extraordinarily intricate entities, somewhat like an old-fashioned watch with many wheels and cogs and so forth.

So there are three ways by which change could occur in living creatures. One is natural selection, the second is drift, and the third is self-organization. By and large, adaptation of living creatures is so pervasive that we are left with no explanation other than that of natural selection to account for essentially agreed traits that we see in the living world. But there are well-known exceptions as well. Inherent in natural selection is the belief that the process of change is slow. The reason why the process of change has to be slow is because of the feature of adaptivity. The one characteristic of the Darwinian view of natural selection is that, to the extent that evolution works by natural selection, evolution must be a slow and gradual process. It cannot occur by jumps. The old word for this was 'saltation'. So evolution cannot be a saltatory process.

Finally, there is something interesting called the principle of continuity which is to say that if evolution is a slow process and if evolution involves ancestors giving rise to descendants who will in turn become ancestors and give rise to descendants and so on, at least mentally or on a piece of paper, you can try and draw lines linking ancestors to descendants. If you can do that, it must also be admitted that these ancestors were common descendants that we have today, that you take any two living creatures around today and link them to each other by drawing these lines. You cannot link a human being to a birds directly, but if you go sufficiently back in time, humans and birds must have had common ancestors. So, in that sense one can link the two. Darwin made use of an image of a tree with all creatures lying on the tip of the branches. Therefore, every living creature is a link to every other living creature because from that tip you can come back to the main stem, the main branch and then go back to the other branch.

Behavioural traits

Are there any reasons for thinking that in addition to physical traits, the behavioural traits have also evolved from natural selection? The answer is: Yes they have. There are three broad reasons for saying this. The first reason is that we see both similarity and variation in behaviour. For example, motor behaviour or movement which is common to all living forms. Let us see the way a human picks up something and a monkey picks up something. It is almost similar. So the extent of motor behaviour is almost similar. At the same time, these movements are not identical. As is well known, none of the apes have an opposable thumb in the way we have. So there are differences as well.

Behaviour is heritable and we know this from laboratory experiments and we record these heritable changes in behavioural patterns which are called genetic mutations and quite often these are experiments done with simple animals. Sometimes in human beings too due to unfortunate accidents in the past, history of their parents and so on, mutations do occur, behavioural changes do occur which can then be passed down to future generations. Many examples are available where genetic mutations alter the behavioural traits in animals. One case which has been studied in depth may be cited here. That is the 'Study of Mating Behaviour in Flies'. It has shown that you can pinpoint, maybe half a dozen genes which, when mutated, specifically affect certain elements in the mating programme.

Another thing which is not related really to natural selection directly, but what we call the so-called higher animals probably started from something called 'hydra' to which Professor Santosh Mukherjee made fundamental contribution at one time. It is very primitive animals which were endowed with what is called the nerve-net. So, probably, starting from the hydra to human beings, we have a thing called the nerve-cells with certain special properties which have worked as a substratum of essentially everything incorporated in behaviour. Bacteria do not have nerve-cells. There are many single-celled organisms—amoeba, parasites—which do not have nerve-cells, but they also show interesting forms of behaviour. In the so-called higher forms of life, however, nerve-cell is the substratum of behaviour which is common across all these creatures. So there is some ground for thinking that the functional basis of behaviour also shares a common angle, given that the structure is the same.

Now, what is this nerve-cell? It is like any other cell and one of the basic building blocks of our bodies and bodies of any other organism. The interesting thing about the nerve-cell is that it is capable of behaving in an all-organ fashion. That is, a stimulus to a nerve-cell can give rise to a response which is very analogous to the response shown by an electronic switch. Biologists use the word 'fire'. They say, a nerve-cell can fire. In modern language, a nerve-cell works perhaps like a small integrated chip in a computer. This nerve-cell can connect together with other nerve-cells to give rise to enormously complex structures, the most complex known to us, ie the human brain. This complex structure can process and receive information. It can also send out information to be made use of by the motor structures of the body to elicit behaviour. So there is enormous power inherent in the brain, not necessarily the human brain; but this is the strongest in the human brain. This power resides in the ability of the nerve-cells to behave like the switch, which I already mentioned, and in the ability of the nerve-cells to form associations with many other nerve-cells. These associations of nerve-cells mean that if you have number of nerve-cells arranged around the perimeter of a circle capable of exiting each other, you might have a situation in which one nerve-cell fires and excites the second, which again excites the third, which in turn excites the fourth and which again excites the first. So you immediately have the possibility of a self-sustained, continuing form of activity. Thus these nerve-cells, even though normally they respond to the stimuli from outside, because of their traits of excitability and connectivity they can form internal states of their own which suddenly become an entity in itself. A group of four nerve-cells keep firing among themselves and the pattern of firing goes round and round circle because it has been presumed to be arranged so. This arrangement is simple. But more complex set-up will have more complex and interesting possibilities of arrangements. In fact, there exists the possibility of entirely autonomous representational states being set up within these nerve-cells which now are no longer linked to the outside world but which can be entirely internally generated and internally sustained.

The last property is slightly a technical property and this is the property at the level of the nerve-cell—small groups of nerve-cells. One calls this 'Experience-Dependent-Modification'. This is an experimentally observed fact. It means that there are two nerve-cells—A and B—and it appears that the activation of A is always accompanied by the activation of B for certain reasons. If that happens, then the connection between A and B gets strengthened. This essentially underlines what people call the 'Conditioned-Learning—the Pavlovian Response.' So there is something in the physical properties of nerve-cells themselves which is conducive to what we call learning.

Sensory perception

One aspect of mind certainly is sensory perception, ie image that we have of the outside world. Be it a visual image or an image which has been developed by a touch or a smell, etc., sensory perception does the work. This you can say without a doubt. We have very good models of how the brain builds up visual pictures of the world based on the primary inputs from the retina, but that picture is an extremely simple picture in terms of our understanding today. The final picture is extremely complex visual world that we see today.

Genetics, which is the science of hereditary transmission and neurobiology, neurophysiology, electrical engineering and computer science, have enabled us to make major advances in understanding that what we called sensory perception could be thought of as a physical trait. The sensory trait too has a very strong case for being fallouts of evolution by natural selection.

Now we come to the heart of the question: Where does the mind come from? As far as the theories of the mind developed by the biologists go, there are, broadly speaking, two ideas—one of them, evolution by natural selection and the other is artificial selection as developed by Wallace, the co-founder of evolution by natural selection as propounded by Darwin.

In evolution by natural selection the idea is that exactly as the other traits have evolved by natural selection, have become adapted to certain needs by a series of genetic variations, in the same way what we think of as the mind, the human mind, has evolved as a series of simpler minds. Indeed, people go to the extent of saying that even though those simpler minds are not seen today as the past is not seen, they can be seen via the principle of continuity, traces of those simpler minds in other creatures today. This was by and large from Darwin's point of view. The co-discoverer of natural selection did not agree with this and he seemed to believe that the human mind in particular is on a plane by itself and some other principles are needed to account for the evolution of the human mind. Wallace did agree that animals do have a mind. But he thought it as what is called the emergent property, ie the analogy between the ice and water which was explained earlier. Wallace said, in some sense the human mind has risen. Later he said that the human mind may have evolved by artificial selection in the sense that horticulturists evolve useful trees and plants, or an animal breeder evolves useful traits in an animal.

Human mind

In general, the belief among biologists is that it is useful to think of the mind as a product of natural selection but the details still need to be filled in. However, on the whole, it appears, based on the evidence around us, the mind too has evolved. If the mind is the product of evolution by natural selection and if we believe in the principle of continuity which really is an element of natural selection, then one has to ask the question: Do other animals have the mind? Here, by and large, the belief among the biologists based upon the tools of experimentations and observations is that the animals have an enormous range of capabilities for which the most economical explanation is that there is something akin to the mind. Now people split hairs and say animals can do a great deal. But they cannot do. For example, animals cannot do mathematics, algebra. To many people it seems like hair-splitting. It is true of course. Then what evidence should we have that we have mind and animals do not? Learning and memory? It is present in a huge range of animals. Emotional behaviour? Anyone who has kept a pet knows that pets have emotions.

Darwin wrote a famous book on emotions where he tried to point out that emotions must have a role to play in the lives of animals including human beings. J. B. S. Haldane, a distinguished citizen of this city, if I may say so, many years ago wrote a famous paper where he pointed out the link between the emotional states and the physicl states. It is obvious that emotional states affect our physical states. For example, in a bad temper, a person starts sweating, starts shaking, etc. But by dint of physical exercise one can affect the emotional states. This is a philosophical point of view. Haldane was a polymath. He pointed out some interesting facts of stage direction in Shakespeare's plays. For example, in a battle scene, the soldiers go through various kinds of physical movements just to work up a feeling of rage within them.

There is also one famous book by Kohler where he has discussed about the chimpanzees. He says, if a bunch of bananas hang high from the roof of their room they would not get easy access to them. However, Kohler had kept some ordinary wooden boxes in the room. Very soon one of the chimpnzees jumped on one of the boxes and tried to reach the bananas. It did not work. So the chimpanzee got frustrated, annoyed and tried to throw things around and finally gave up. Kohler then describes that after many a fruitless attempt suddenly a chimpanzee took a big box and kept it down below the hanging bananas and then put a small box atop the big one and then jumped on it and ultimately got the bananas. He describes this fact as an instance of insight. Now, what is insight if it is not a property of the mind?

Not very long ago, there was a famous Japanese experiment on the macaw. The experiment is known as 'Washing Behaviour.' A group of researchers fed the macaws on sweet potatoes. The macaws were all on an island and the sweet potatoes were thrown on the sand. The macaws while eating the sweet potatoes found the sandgrains very uncomfortable. Then one day a young female macaw named 'Emo', her name has become immortal in biology literature, dipped it in the sea, washed it and then ate it. Now it has become a behavioural trait in them and now I believe that the macaw in that island routinely wash their sweet potatoes and eat them. So this reveals not only a behavioural trait, or a mental trait, but a trait which has been transmitted.

Something remarkable has come up in neurobiology. An Italian neuropsychologist called Ressolatti was sticking electrodes into monkey brains to study what is called the motor cortex. It is that part of the brain which sends signal which finally results in motor movements. Then he made a discovery that whenever the monkey made a movement, slightly before the movement, a set of neurons in the motor cortex, started firing as expected. Then by serendipity he discovered that the electrodes were struck in the wrong place; in other words, not in the motor cortex, and still the neurons seemed to fire when the monkey made a movement. Things got even more interesting because he discovered accidentally that those electrodes were left in the monkey. He also discovered by experimenting on some other monkies that these neurons started firing when some other monkies started doing some movement. This gave Ressolatti a great insight. These are now called mirror neurons. These are neurons which in some sense within the brain seemed to mimick motor activity whether carried on by oneself or by others and these are always anticipatory of such activity. These are not nerve-cells which direct motor activity but these are nerve-cells which mirror motor activity.

It can be seen here that these mirror neurons are constructing essentially for the monkies an internal state in the brain. They are not involved in actually directing the movements but are involved in representing the movements most importantly, representating the movements whether they occur in that monkey or in some other monkey. This means that this monkey can build up representational states within its brain of activities performed by some other monkey.

Language

But there are some qualitatively interesting things which distinguish human beings from some other animals. One of them is the language; of course, in the sense we human beings understand it. Language is the ability to construct symbolic representations of the outside world and to convey it symbolically by using appropriate signals. The most common signal is the series of vocal sounds generated by the larynx. But we can also use hand signals and others. So the question is: Is this a peculiarly human trait or not. There are people on both sides of the divide.

Are traits like altruism (Darwin called it Higher Moral Quality) or nurturing of children by their parents, etc peculiarly human? People differ because things which look like altruistic traits are certainly found in other animals.

ext comes culture. Here also there are people on both sides of the divide. There are certain traces of cultural dimension in animals also. As for example, the washing behaviour culture of the Japanese macaw.

Having said all this, what is the most parsimonious conclusion that one can draw? Where are we today on this question of evolution? It can be expressed with the help of two or three different propositions. 1) Evolution permeates all of biology. 2) The dominant form of evolution has to be natural selection. 3) Are humans a special entity in this chain of beings? Definitely not. For, all the evidences that we have now show that human beings also fall squarely somewhere on the evolutionary tree.

Then again, are humans something special in terms of their behavioural capability and in terms of the structural substrate of those behavioural capabilities? Broadly speaking, no. Certainly not in most forms of motor behaviour. In terms of structural substrate, not at all, in the sense that the nerve-cell is common to a huge variety. Where you do get a difference is in the number of nerve-cells, or in the size of the cerebral cortex in the human brain. Thus there is no doubt that no other brain of any living creature today comes close to the size of the human brain. More than the large size of the brain, it is the enormous complexity of the human brain that counts. This complexity is staggering. If you try to give a number to the complexity, you will end up with a number which is mind-boggling. The adult human being has something like a million millionth, 1012, nerve-cells. Each of those nerve-cells on an average makes connections as wires to thousand other nerve-cells. In fact, David Hubel, one of the most distinguished students of neurobiology, who pioneered our perception of visual understanding, had gone so far to call human brain as one of the most complex entity in the universe. At the time there is no reason for believing that what we call the mind has the basis of its existence outside the brain.

Now we are left with the question: How to account for the complexity of the brain? At present there are two theories and both of which in a literal sense are materialistic theories. One of them is evolution by natural selection and the other which says that there was some period in proto-human evolution during which there was rapid expansion of brain size due to something else, correlated probably because of the increase in body size from the primitive mammal to other size, who knows. But this rapid expansion of the brain size indirectly led to the brain acquiring properties that we associate with higher mental functions. For example, writing poetry, reading philosophy. So, things of these kinds arose of emergent properties from our brain which had evolved from something quite different. On this matter, I think, people still differ .

In conclusion, I must say that it is not an answer to all the questions that link evolution and the mind, but I have tried to give rather a series of snippets concerning what evolution is all about, what our understanding of the mind is all about and why we think that the two have something to do with each other. I end by saying that nobody doubts that the mind is a product of evolution simply because there are no other ways that one can conceive of it. Where people do differ is on the question whether the mind is a product of evolution purely by natural selection or whether the mind in some sense is an entity that has arisen simply because of the pre-existing complex structure of the brain.

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