

## **Science, Methods of Science and Scientific temper**

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We are often encountered with a common question “What is Science?” The answer to this question is not so simple. Science cannot be defined easily. It is better to understand it with the help of some examples. Let us try to understand what science is.

#### **What is Science**

We always gather information about our surrounding. Better to say, about the world. Five sense organs help us in doing so. Whether a substance is red or blue, round or square, even or uneven, eyes provide us that information. Ear let us know whether it is crow or cuckoo, dog or cat is calling. Noses inform us about the fragrance of a flower or nasty smell of a drain. Similarly whether a substance is sweet or sour, that information was provided by our tongue. And skin, which spread throughout our whole body, informs us whether the substance is hot or cold, smooth or rough, etc.

These are outer sense organs. There are internal sense organs also. They are responsible for our anger, happiness, sorrow, shame etc.

These sense organs provide us number of information. That information makes us knowledgeable. Thus, with their help, we can expand our knowledge about our universe. This knowledge is true and bound to be true as the information are true.

We can also have some information which is not directly provided by the outer sense organs. As for example, if we see profuse smoking in a distant place we can easily say that presently there is fire in that place. Similarly after seeing a malaria patient we can easily say that he or she must have suffered a mosquito-bite in the past. We are not visited fire or mosquito-bite incident directly. But these are assumptions or conclusions which can easily be drawn from the above facts. They are proven, and are found always true. In the same way doctor provides penicillin injection to a pneumonia patient with symptoms of fever, cold and cough, and head & chest pain. At the same time he assures the patient about definite relief within a day or two. So the doctor here speaks about what is going to happen in future. But we yet not observed that.

Though these incidents are not directly observed by our sense organs, but our previous knowledge about them are true. So the assumptions or conclusions are also true.

Who provided us this true knowledge? It is SCIENCE.

So SCIENCE is such a thing which helps us to find TRUE KNOWLEDGE. Knowledge offered by science is bound to be true as they are collected from information of sense organs and valid assumptions.

#### **Observation**

Hence, science is nothing but a method for gradually gaining knowledge of nature. For that purpose we have to come to nature, observe it closely, and observe it critically.

This ‘observe’ term is very important. This is not mere seeing. It is actually watching for time and again. Watch the object for number of times. Find any difference between two watches. Watch it minutely and critically.

In case of solar eclipse, scientists observe that, the shadow of moon is actually spreading over earth. But

large number of people considers that Rahu is swallowing the Sun. They believe it because they used to hear this story from their childhood. So, the science observes any incident to judge it without any faith. Here it differs from religion or blind faith. Religious people and people of blind faith never try to judge any Incident critically. They only remain faithful to their scriptures.

Observation is thus very much important. Several tools can expand the observational power of human being. Simple examples are microscope and telescope. The former extends our vision for smaller objects and the later for objects at a high distance. These instruments are responsible for number of revolutionary discoveries. So, observation is a method of science by which man can find the truth of nature.

### **Experimentation**

Scientists in their laboratory try to observe certain incidents critically and for number of times. This is called experimentation. Say a set of rats were subjected to all vitamins required for their normal growth, whereas another set was without Vitamin B. After few days it will be observed that second set of rat was attacked by Beriberi. The conclusion can be drawn from this experimentation is that, Vitamin B deficiency causes beriberi. So, true knowledge can also be drawn from experimentation. Thus Experiments along with observation are the methods of science. Mind it; incidents in laboratory are also natural incidents. So experimentation also finds truth for certain incidents.

### **Jumping from known to unknown!**

Hence by observation and experimentation we can find information and gain true knowledge about some incidents. But how many facts of similar nature we can observe, or experiment in our lifetime. Those will be very few. But we want to have a generalized knowledge about those facts. How can we get that? We can do it simply by using assumptions based on experimental and observational results about those facts. This can be a case of ***jumping into unknown from known facts***. This can provide us some generalized rule of nature. Thus it is a scientific knowledge.

Scientific knowledge is always true and bound to be true.

### **Why that is necessary?**

One example in this regard will be very helpful to understand the situation. Paramita attacked to malaria at Pune. I personally observed the entire incident. That is a true knowledge but not a scientific knowledge. Because, we know, without generalization we cannot claim it as scientific fact. 'All who returned from Pune are Malaria patient' or, 'whoever gone to Pune are attacked by malaria' can be claimed as a scientific knowledge. Hence using assumptions scientists always try to generalize the fact under study. And they do that simply by jumping to 'assumptions' with the help of pre-gained true knowledge about the fact and application of causality. As he can jump to the conclusion of existence of fire wherever there is smoke.

### **Causality**

From known fact scientists always can predict an unknown fact. They can do that by using one very important rule. That rule is known as ***cause and effect relation***. According to science, behind every incident there is a cause. The incident is actually an outcome of the cause.

Now the question is, how a scientist become able to find the cause?

***First very important idea in searching the cause is that, it occurs prior to the incident under study.***

First hanging then death

First mosquito bite then malaria  
First spicy food intake than stomach upset

But, one can say several incidents may occur before a person was attacked to malaria. Which one is the cause? There may happen-

Change of prime minister of Germany  
Increase in food price in India  
Mosquito bite  
Three years before the person suffered a head injury  
Sudden fall in a slippery road

Now see out of all these incidents last two may have certain link with the incident under study. Three year is a long gap and head injury at that time could not be considered as the cause. Again it is our experience that all people who suffers a fall in road or suffered head injury does not always attacked by malaria. Thus we can conclude,

***The cause is an incident without which the 'incident under study' could never happen.***  
***The cause and incident should never have much time lag.***  
***No other incident can interfere with the cause.***

Now the question is how we can discover the cause?

**Case 1**

Ram has eat rice, frozen meat curry and motor pannier  
Raghu has eat rice, pulses and frozen meat curry  
Rajen has eaten motor pannier, frozen mat curry and pulses  
All have suffered a stomach upset.  
Other people who simply eat rice, pulses, motor pannier have no such complain.  
Hence, cause of stomach upset of Ram Raghu and Rajen is frozen meat curry.

**Case 2**

We won all the matches when Rahim played  
We lost the matches where Rahim not played  
Hence, cause of our win is Rahim.

**Case 3**

Biplab eat frozen meat curry and tobacco leaf  
Biplab suffered stomach upset and nausea.  
Now we know that frozen meat curry is the cause of stomach upset.  
So, the cause of nausea is tobacco leaf.

**Case 4**

Two rats kept in two cages in a laboratory  
Both are given similar meals  
But to Rat 1 with vitamin B and Rat 2 without vitamin B  
This was continued for long  
We will find that rat 2 was attacked with Beriberi.  
Hence, Cause of beriberi is vitamin B deficiency.

***This way of finding cause by experimentation (as in case 4) is very important.***

Thus science always finds explanation to the incidents of nature. These are natural laws.

How can we prove that the findings of science are always true?

The answer is, simply by applying it.

Pneumonia will be cured by applying penicillin.

Prevention of mosquito bite will prevent malaria

Lemon is sour and sugar is sweet can be proved by testing them

On heating an iron rod expands, and that expansion can be measured.

***All these and several other applications of science surrounding us strengthen its validity.***

So unveiling the mystery of nature is science. It's nothing but knowledge. It's true knowledge of nature.

And by its application we can conquer the nature.

***Hence the function of head and hand in science are very important.***

### Characteristics of science

***"The two most notable features of scientific methodology are its critical spirit – that is , a commitment to put your beliefs to stringent tests and revising or discarding those ideas that fail the test; and fallibilism, that is , the understanding that all our knowledge is open to revision in the light of better evidence". (Alan Sokal, Archaeological fantasies, 2006)***

***Other notable features of science are:***

***a) It is guided by natural laws.***

***b) It has to be explanatory by reference to natural law.***

***c) It is testable against the empirical world.***

***d) Its conclusions are tentative, i.e. are not necessarily the final word.***

***e) It is dynamic in nature***

***f) It fundamentally oppose fundamentalism***

***g) It is always in a state of trying to question and refute***

***h) It can be reconstituted,***

***i) It is secular, democratic and international in character***

***j) It is falsifiable***

### Scientific Temper

The term 'Scientific temper' was first coined by Bertrand Russell in his essay "On Education". This essay was published in 1926. But Jawaharlal Nehru used and explained the term widely. To talk on Nehruvian view of scientific temper, we must refer to his various lectures on this point. In his message to the silver jubilee session of the Indian science congress Association in January 1938, Nehru wrote- ***"..I realized that science was not a pleasant diversion and abstraction, but was a very texture of life, without which our modern world would vanish away. Politics led me to economics, and this led me inevitably to science and scientific approach to all our problems and to life itself. It was science alone that could solve these problems of hunger and poverty, of insanitation and illiteracy, of superstition and deadening custom and tradition, of vast resources running to waste, of a rich country inhabited by starving people."***

Nehru also wrote much about scientific temper in his famous book 'The Discovery of India'. This book was published on 1946, and in it he wrote- ***"The applications of science are inevitable and***

*unavoidable for all countries and peoples today. But something more than its application is necessary. It is the scientific approach, the adventurous and yet critical temper of science, the search for truth and new knowledge, the refusal to accept anything without testing and trial, the capacity to change previous conclusions in the face of new evidence, the reliance on observed fact and not on pre conceived theory, the hard discipline of the mind – all this is necessary, not merely for application of science but for life itself and the solution of its many problems. ...The scientific approach and temper are, or should be, a way of life, a process of thinking, a method of acting and associating with our fellowmen. ...The scientific temper points out the way along which man should travel...Science deals with the domain of positive knowledge but the temper of science which it should produce goes beyond that domain.”*

To have a full idea on Nehruvian outlook of scientific temper, we must re read his address in the inauguration of ‘National Physical Laboratory’ in 1950. There he mentioned, ‘**Large number of people talk glibly about science today and yet in their lives or actions do not exhibit a trace of science... So stress the need for the development of a scientific mind and temper which is more important than actual discovery as it is out of this temper and method that many more discoveries will come.**’

Nehru also mentioned in his Indian science congress speech in 1957, that the message of this spirit of ‘Scientific outlook’, or ‘Scientific approach’, or ‘scientific method’ was there in teaching of Buddha and Upanishad. Message of Buddha, Nehru said, ‘**...apart from its religious significance, was a message of tolerance, a message against superstition, rituals and dogma. It was a message essentially in the scientific spirit.**’ Teaching of Upanishad also, according to Nehru, as he expressed in 1958 in his address to the students of university of Guwahati, ‘**.is not an idea of bigot, is not the approach of a closed mind , but of an open mind, of enquiry, realizing a special way of thinking as it used to be in India.**

Debiprasad Chattopadhyay also has shown in his famous book Lokayata that a strong materialistic orientation was very much there in traditional Indian culture along with its well known spiritualism. That outlook was committed to secularism, rationalism and science orientation. That thought was never taken into the surface by the ruling society in their class interest.

#### **Statement of scientific temper-1981**

In addition to this approach, another statement of scientific temper is there. Some eminent academicians and scientists assembled at Nehru centre in Mumbai in July 1981 to formulate this statement. The statement says-

- That the method of science provides a viable method of acquiring knowledge.
- That the human problems can be understood and solved in terms of knowledge gained through the application of the method of science.
- That the fullest use of method of science in everyday life and in every aspect of human endeavor from ethics to politics and economics is essential for ensuring human survival and progress .
- That one should accept knowledge gained through the application of the method of science as the closest approximation of truth and question what is incompatible with such knowledge; and that one should from time to time reexamine the basic foundations of contemporary knowledge.

### **Srirupa Roy's observation**

1. Scientific temper refers to a mentality or an outlook rather than a specified body of knowledge. It addresses itself to universalists' concern of "value of life" rather than to narrow and specified question of scientific research and application.
2. Unlike scientific expertise alone, scientific temper is a call for diffusion of scientific mindedness throughout the population. The growth of scientific temper is measured by the extent to which common people were using the method of science to life's problems. [In her book *Beyond belief: India and the politics of post colonial nationalism*]

### **Palampur Declaration: 2011**

#### **Dabholkar : What is scientific temper ?**

**"If one has to say in a single sentence, what is scientific temper, then this is it – "As much belief as there is evidence for". This means that we use scientific temper ourselves to live our daily lives." One can remember his famous sentence-**

‘जेवढा पुरावा, तेवढा विश्व िश्व िस

#### **Definition of scientific Temper**

Let us try to define scientific temper. 'Scientific Temper can broadly be considered as thinking and

re-thinking rationally or logically about everything that we do, analyzing every thought, belief, concept and action with a critical eye, try to find out whether it is right or wrong, and also make effort to find out an optimum way of doing any task'. It is not necessary to be a science student to profess scientific temper but could be interested in science because it is where the frontier lies. Certainly the awareness of science is an important component of scientific temper.

***Secularism is an inseparable part of scientific attitude and progressive outlook.*** The word "secularism" is derived from the Latin word for "world". Secularism refers to system of thought and belief, which explicitly or implicitly excludes God from human affairs. In short, secularism proclaims that the world we live in is all there is, --- there is no God, or if there is, He is beyond our Understanding to be of any relevance to human life today.

***Some people try to say that the idea of secularism and scientific temper is western.*** In India the colonialists coined the slogan "East is east, and West is west". That is east is spiritual and west is material. However the ideas of scientific temper were promoted by reformers like Raja Rammohan Roy, Vivekananda, Narayan Guru etc. Therefore calling Indian secularism as an import from its western origin is an insult to those reformers.

***Indian freedom movement also imbibed the spirit of secularism and scientific temper.*** Most of the leaders and groups are modern or of progressive outlook. The emergence of secularism in India parallels its evolution as a national state out of inherently heterogeneous units via anti-colonial struggle. Thus

Indian secularism is anti-imperial, anti-hegemonic, pluralist, inclusive and accommodating in flavor.

### **Constitutional binding**

In 1976 through the 42 amendment part IV-A Article 51A on Fundamental duties got added to our constitution. Our particular interest is Article-51A(h) which reads:

***(It shall be the duty of every citizen of India) to develop the scientific temper, humanism and the spirit of inquiry and reform.***

This is a very important tool in our hand for propagating the idea of scientific temper among common mass.

### **Focus and task ahead**

1. Rationalism and scientific temper cannot be promoted without education in general and science education in particular. This is a tool which can help them to distinguish between obscurantism and science, between superstition and religion. Though it is a pre requisite it never guarantees rationalism and scientific temper. 'Milk miracle' was largely taken by educated middle class people of India. Here scientists often found significantly lacking in scientific temper. In spite of that, constant attempt to deliver good quality science education may be an important tool for generating scientific temper.
2. Methods of science are to be taken in clear conception to propagate it among the common mass. At least the concept of critical thinking, fallibilism, verifiable observation and evidence based learning are to be understood and propagated to develop a progressive and scientific mindset.
3. Rationalism, materialistic outlook and following a modern mindset is our historical and political tradition. Debiprasad Chattopadhyay proved the existence of materialistic thought in ancient India in his book 'Lokayata' and 'Science and Society in Ancient India'. We can never forget the contribution of Rammohan, Vidyasagar, Vivekananda and Narayan Guru in our social reform. During Indian freedom struggle these outlook was followed by our national leaders like Nehru, Periyar and Bhagat Singh. So, as a social and political tradition, principles of rationalism need to be actively propagated.
4. Main opposing force in this path is the followers of Hindutva science movement, Vigyan Bharati. They inculcate and propagate the outlook of 'Science with Swadeshi spirit'. They object vividly the 1981 'Statement on Scientific Temper' (SST) as a western scientific concept and campaign the idea of 'Patriotic and people oriented science and technology' (PPST). We have to combat this outlook exhaustively.
5. Fundamentalist forces always present their mythology as history and their theology as the proper ideology or philosophy. With the political rise of major religious and fundamentalist force in India this tendency has become more aggressive. As they are presently in state power hence imposition of their ideology become easier. Advancement of this theological and mythological input into our education system and science and technology institutions will definitely oppose the concept of science in general and scientific outlook in particular. We should be aware of that.

6. Fundamentalist forces never intend to propagate free and fair basic research as they always lead to disprove their viewpoint. We lack in first rate facilities in our laboratories but possess a good number of willing researchers. Without the first the willing researchers are forced to go abroad to pursue their research career. More and more public funding is necessary to improve this situation. Allocation of at least 3% of GDP in research and 10% in education is a dare need. At the same time we should oppose waste of public money in researches leading to cultivation of pseudoscience and anti science.

7. As a constitutional obligation we should firmly perform our duty of developing scientific temper, humanism and spirit of inquiry and reform.