PHYSICAL WORLD

1. Some of the most profound statements on the nature of science have come from Albert Einstein, one of the greatest scientists of all time. What do you think Einstein meant when he said: "The most incomprehensible thing about the world is that it is comprehensible"?

Ans: Since the physical world around us appears to be full of different complex natural phenomena, the world is considered in-comprehensible.
But with the help of study and observations one would find that all these phenomena are based on some basic physical laws and hence comprehensible.

2. "Every great physical theory starts as a heresy and ends as a do gma". Give some examples from the history of science of the validity of this incisive remark.

Ans: The above statement is true.
Validity of this incisive remark can be validated with the help of the example of moment of inertia.
It states that the moment of inertia of a body depends on its energy.
However, according to Einstein's mass-energy relation, energy depends on the speed of the body.

3. Politics is the art of the possible". Similarly, "Science is the art of the soluble". Explain this beautiful aphorism on the nature and practice of science.

Ans: We all know that to win over votes, politicians would make anything and everything possible even when they are least sure of the same.
Similarly, in the case of science the various natural phenomena can be explained in terms of some basic laws.
So as 'Politics is the art of possible', similarly 'Science is the art of the soluble'.

4. Though India now has a large base in science and technology, which is fast expanding, it is still a long way from realizing its potential of becoming

a world leader in science. Name some important factors, which in your view have hindered the advancement of science in India.

Ans: Some important factors in our view which hinder the advancement of science in India are:

1) Proper funds aren't arranged for the development of research work and laboratories. The labs and scientific instruments are very old and outdated.

2) Most of the people in India are highly traditional and uneducated. So, they don't understand the importance of science.

3) Employment opportunities are also very low.

4) Facilities for science education in schools and colleges in India are very poor.

5. **No physicist has ever "seen" an electron. Yet, all physicists believe in the existence of electrons. An intelligent but superstitious man advances this analogy to argue that 'ghosts' exist even though no one has 'seen' one. How will you refute his argument?**

Ans: No physicist has ever seen an atom, however there is practical evidence which proves the presence of electrons.

Their size is so small that even powerful microscopes can't measure their sizes but its effects could be tested.

On the other hand, there is no such phenomena that could prove the existence of ghosts.

Though our senses of sight and hearing are very limited to observe the existence of both, experimental evidence is enough proof for any scientist.

6. **The shells of crabs found around a particular coastal location in Japan seem mostly to resemble the legendary face of a Samurai. Given below are two explanations of this observed fact. Which of these strikes you as a scientific explanation?**

a) A tragic sea accident several centuries ago drowned a young Samurai. As a tribute to his bravery, nature through its inscrutable ways immortalized his face by imprinting it on the crab shells in that area.

b) After the sea tragedy, fishermen in that area, in a gesture of honour to their dead hero, let free any crab shell caught by them which accidentally had a shape resembling the face of a Samurai. Consequently, the particular shape of the crab shell survived longer and therefore in course of time the shape was genetically propagated.

This is an example of evolution by artificial selection.

[Note: This interesting illustration taken from Carl Sagan's 'The Cosmos' highlights the fact that often strange and inexplicable facts which on the first sight appear 'supernatural' actually turn out to have simple scientific explanations. Try to think of other examples of this kind].

Ans: Explanation (b) could be considered as a correct scientific explanation of the observed fact.

7. **The industrial revolution in England and Western Europe more than two centuries ago was triggered by some key scientific and technological advances. What were these advances?**

Ans: More than two centuries ago, England and Western Europe made inventions like steam engines, electricity, theory of gravitation and explosives. Steam engines helped them in the field of heat and thermodynamics, theory of gravitation in the field of motion and making guns and cannons.
These progresses lead to industrial revolution in England and Western Europe.

8. **It is often said that the world is now witnessing a second industrial revolution, which will transform the society as radically as did the first. List some key contemporary areas of science and technology, which are responsible for this revolution.**

Ans: Some of the key contemporary areas of science and technology which may transform the society radically are the following:
1) The development of super-fast computers.
2) Internet and tremendous advancement in information technology.
3) The development in Biotechnology
4) The development of superconducting materials at room temperature
5) The development of robots.

9. **Write in about 1000 words a fiction piece based on your speculation on the science and technology of the twenty-second century.**

Ans: Imagine you are in a spaceship along with your friends which is moving towards Mars. The body of the spaceship is made of a specially designed matter which becomes harder as its temperature increases. The spaceship is using nuclear fuel and has three nuclear power plants in it. Two of them work alternatively and the third is kept for emergencies. The energy produced at these power plants is converted into electric energy which in turn runs the motors of the spaceship.

Your team reaches safely on Mars, collects data, takes photographs and then returns back to the Earth. Unfortunately, on the return journey, the spaceship collides with an object in space and two of the power plants stop working as a result. Also, the third power plant's efficiency is decreasing continuously due to overheating.

You and your friends try to reduce the temperature of the power plant by flowing air in the plant and also try to repair the fuse of the other power plants. Finally, your team manages to repair the fuse of one of the powerplants. At last, you and your friends return safely back to Earth.

10. Attempt to formulate your 'moral' views on the practice of science. Imagine yourself stumbling upon a discovery, which has great academic interest but is certain to have nothing but dangerous consequences for human society. How, if at all, will you resolve your dilemma?

Ans: In our view a type of discovery which is of great academic interest but harmful for human society should not be made public because any advancement in the field of science is meant to improve the society, not to destroy it.

11. Science, like any knowledge, can be put to good or bad use, depending on the user. Given below are some of the applications of science. Formulate your views on whether the particular application is good, bad or something that cannot be so clearly categorized:

a) Mass vaccination against smallpox to curb and finally eradicate this disease from the population. (This has already been successfully done in India).

Ans: Good. This was one of the major discoveries in the field of medical science and could save many lives.

b) Television for eradication of illiteracy and for mass communication of news and ideas.

Ans: Good. Without doubt television is a big boon as we could know what happens all across the world while relaxing on your couch.

c) Prenatal sex determination.

Ans: Bad. Though it is great that we could know the sex of the baby before it comes out of the womb, female foeticide has shown an increase after this discovery.

d) Computers for increase in work efficiency.

Ans: Good. Computers have in fact made the world a better place and life on it easier.

e) Putting artificial satellites into orbits around the Earth.

Ans: Good. Artificial satellites with all its applications have made communication, etc great.

f) Development of nuclear weapons.

Ans: Bad. No good has come out of this discovery but loss of lives.

g) Development of new and powerful techniques of chemical and biological warfare.

Ans: War is bad and so is this development.

h) Purification of water for drinking.

Ans: Good. Drinking pure water is must to avoid deadly diseases.

i) Plastic surgery

Ans: Good. This could fix innate disfigurement and those caused due to accidents. However, those who could afford this surgery also use it to change features that would make them meet the beauty standards.

j) Cloning

Ans: Good. This could help farmers, etc, to increase the production of that crop or animal showing preferred traits.

12. India has had a long and unbroken tradition of great scholarship - in mathematics, astronomy, linguistics, logic and ethics. Yet, in parallel with this, several superstitious and obscurantist attitudes and practices flourished in our society and unfortunately continue even today - among many educated people too. How will you use your knowledge of science to develop strategies to counter these attitudes?

Ans: Poverty and illiteracy are the two major factors which make people superstitious and hence affect the quality of education in India.
In order to remove the superstitious and obscurantist attitude we have to first fix these factors.

Everybody should be educated, so that everyone can have a scientific perspective. Scientific knowledge can prove people's superstitions wrong by showing them the scientific logic behind everything happening around the world.

13. Though the law gives women equal status in India, many people hold unscientific views on a woman's innate nature, capacity and intelligence, and in practice give them a secondary status and role. Demolish this view using scientific arguments, and by quoting examples of great women in science and other spheres; and persuade yourself and others that, given equal opportunity, women are on par with men.

Ans: Some people in our society believe that the women do not have the innate nature, capacity and intelligence.

To demolish this belief, we could cite the examples of women who have proven their abilities in science and other fields. For example, Madam Curie, Mother Teresa, Indira Gandhi, Margaret Thatcher, Rani Laxmi Bai, Florence Nightingale, etc.

Hence, we could say that, in this era, women are definitely not behind men in any field.

14. "It is more important to have beauty in the equations of physics than to have them agree with experiments". The great British physicist P. A. M. Dirac held this view. Criticize this statement. Look out for some equations and results in this book which strike you as beautiful.

Ans: An equation which agrees with experiment must also be simple and hence beautiful. Following are some simple and beautiful equations in Physics:

1) Energy of light, $E = mc^2$

2) Energy of a photon, $E = h\nu$

3) Kinetic energy of a moving particle, $K.E = \frac{1}{2}mv^2$

4) Potential energy of a body at rest, $P.E = mgh$

5) Work done, $W = F.d$

It is interesting that all the above equations have the same dimension.

One experiment shows dependency of energy on speed, the other shows dependency on frequency & displacement and that's the beauty of equations in Physics coming from different experiments.

15. Though the statement quoted above may be disputed, most physicists do have a feeling that the great laws of physics are at once simple and beautiful. Some of the notable physicists, besides Dirac, who have articulated this feeling, are: Einstein, Bohr, Heisenberg, Chandrasekhar and Feynman. You are urged to make special efforts to get access to the general books and writings by these and other great masters of physics. (See the Bibliography at the end of this book.) Their writings are truly inspiring!

Ans: It is extremely true that great laws of physics are simple and beautiful. Few of the examples are given below.

a) Einstein's mass-energy equivalence relation $E = mc^2$ is simple and beautiful.

b) According to Max Planck's quantum, the energy of a photon is $E = h\nu$, is also a simple and beautiful equation.

c) De-Broglie wavelength associated with a particle of mass m is given by $\lambda = \frac{h}{mv}$. It is also a simple and beautiful equation.

16. Textbooks on science may give you a wrong impression that studying science is dry and all too serious and that scientists are absent-minded introverts who never laugh or grin. This image of science and scientists is patently false. Scientists, like any other group of humans, have their share of humorists, and many have led their lives with a great sense of fun and adventure, even as they seriously pursued their scientific work. Two great physicists of this genre are Gamow and Feynman. You will enjoy reading their books listed in the Bibliography.

Ans: It is very true that scientists like any other group of humans have their share of humorists.

Two great physicists of this genre are Gamow and Feynman. We could also add a few other scientists to this list: CV Raman, Einstein, Bohr, former Indian president. APJ Abdul Kalam, etc.