Physics : Part 1: Video 3 : What is Science ?

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Science : an important part of the Humanities

Science is an important part of the humanities because it is based on an essential human trait; curiosity about the "hows" and "whys" in our environment. We must foster wonder, joy of insight. Such attitudes are crucial not only in the natural sciences but in human relations, social issues, politics and art.

We must be concerned, ask questions and see things from different angles. *There are no pat answers; there is no flat knowledge*. Science can foster an open attitude, helpful in other human activities and culture. It can give us a much fuller, more meaningful life.

V. Weisskopf, *The Priviledge of Being a Physicist*, 1989, Freeman

Contents:

What is Science ?

It is a process : we know so much about nature through this process. Science is more than a body of knowledge. It is primarily a process for proposing, testing and refining ideas.

The notion that knowledge comes from human experience and rational thought and is subject to testing by observation is science's most basic value and probably its most important benefit.

Science is too important to be left to Scientists. The power of science demands great responsibility from us human beings.

A. Hobson, *Physics, Concepts and Connections*, 2010 Addison-Wesley.

Contents:

What is this Process ?

The Scientist :

- Collects data and inspects the data.
- Choose a theory that describes or explain the data.
- Makes predictions, which then are tested to decide the theory's ultimate fate.
- The new scientific theory is then accepted by consensus.

A. Miller, *Insights of Genius in Science and Art*, 2000 MIT Press.

The Method of Science

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Science is a dialogue : between Nature & Mind

Although observation (data) is the beginning of the scientific process, a catalog of observed facts (data) does not add up to an understanding of nature, any more than a telephone book adds up to an understanding of a city.

To understand – literally, to "*stand beneath*" – means to perceive a framework. A framework of scientific ideas is called a Theory. In the development of astronomy, observations stimulated speculations that led to theories, and these theories in turn suggested new observations to check the theories and suggest new speculations. This interplay between observations and theories is the essence of science.

A. Hobson, *Physics, Concepts and Connections*, 2010 Addison-Wesley.

Science is a dialogue : between Nature & Mind

Observation refers to the data-gathering process. A measurement is a quantitative observation, and an experiment is an observation that is designed and controlled by humans (involves error analysis), perhaps in a laboratory.

A scientific theory is a well-confirmed framework of ideas that explains (or describes) what we observe. A model is a theory that can be "visualized", and a principle or law may be one idea within a more general theory.

The word "Law" can be misleading because it sounds so certain. As you will see, scientific ideas are never absolutely certain.

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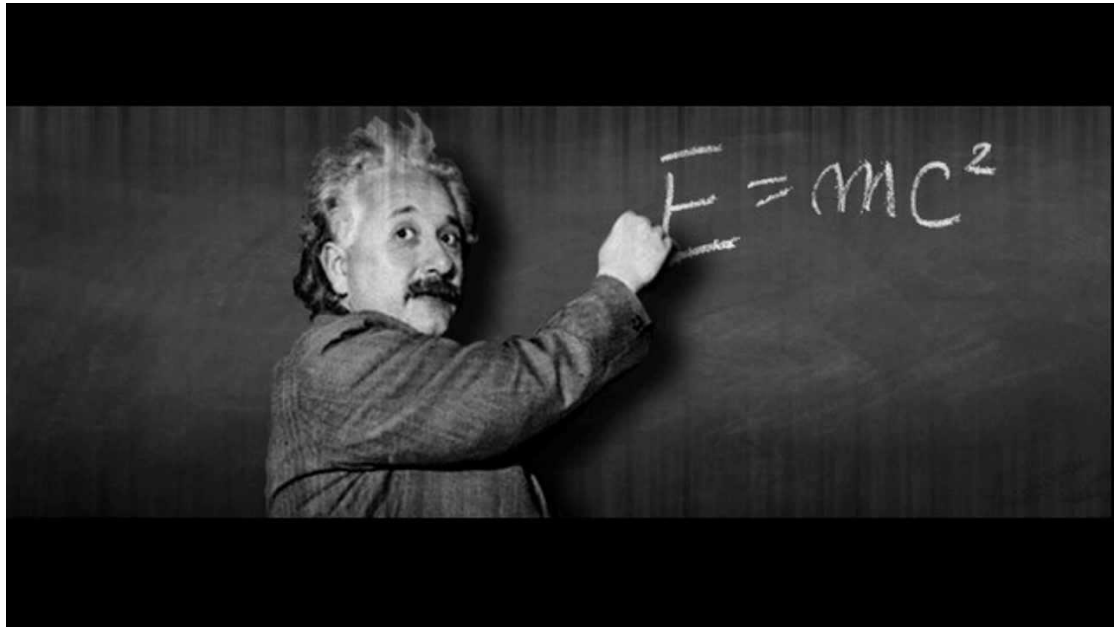
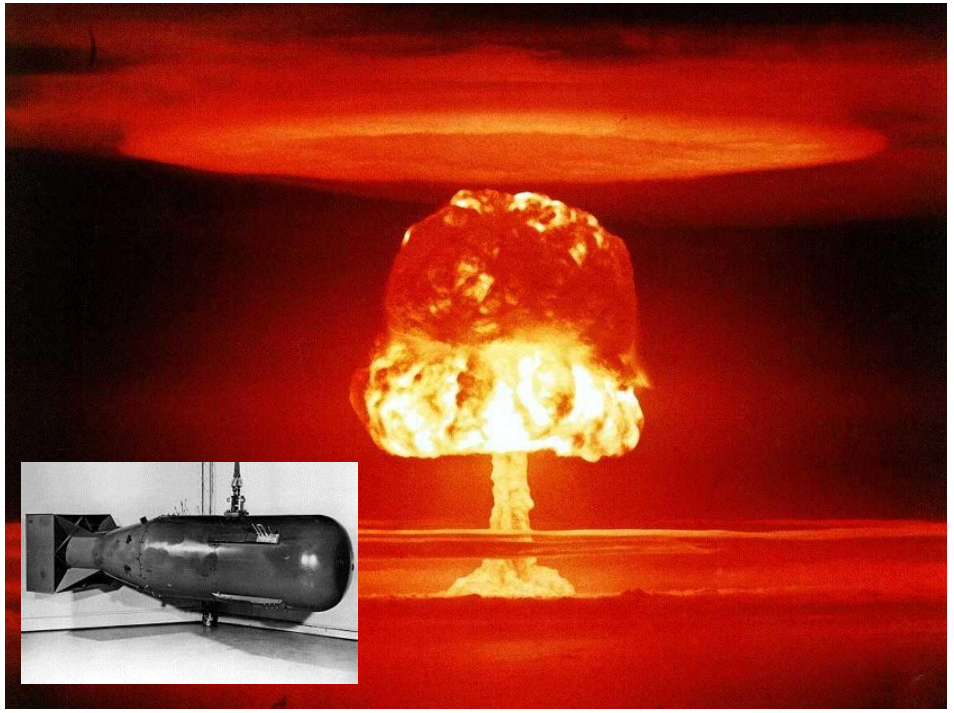
Example : making a Prediction





https://en.wikipedia.org/wiki/Little_Boy

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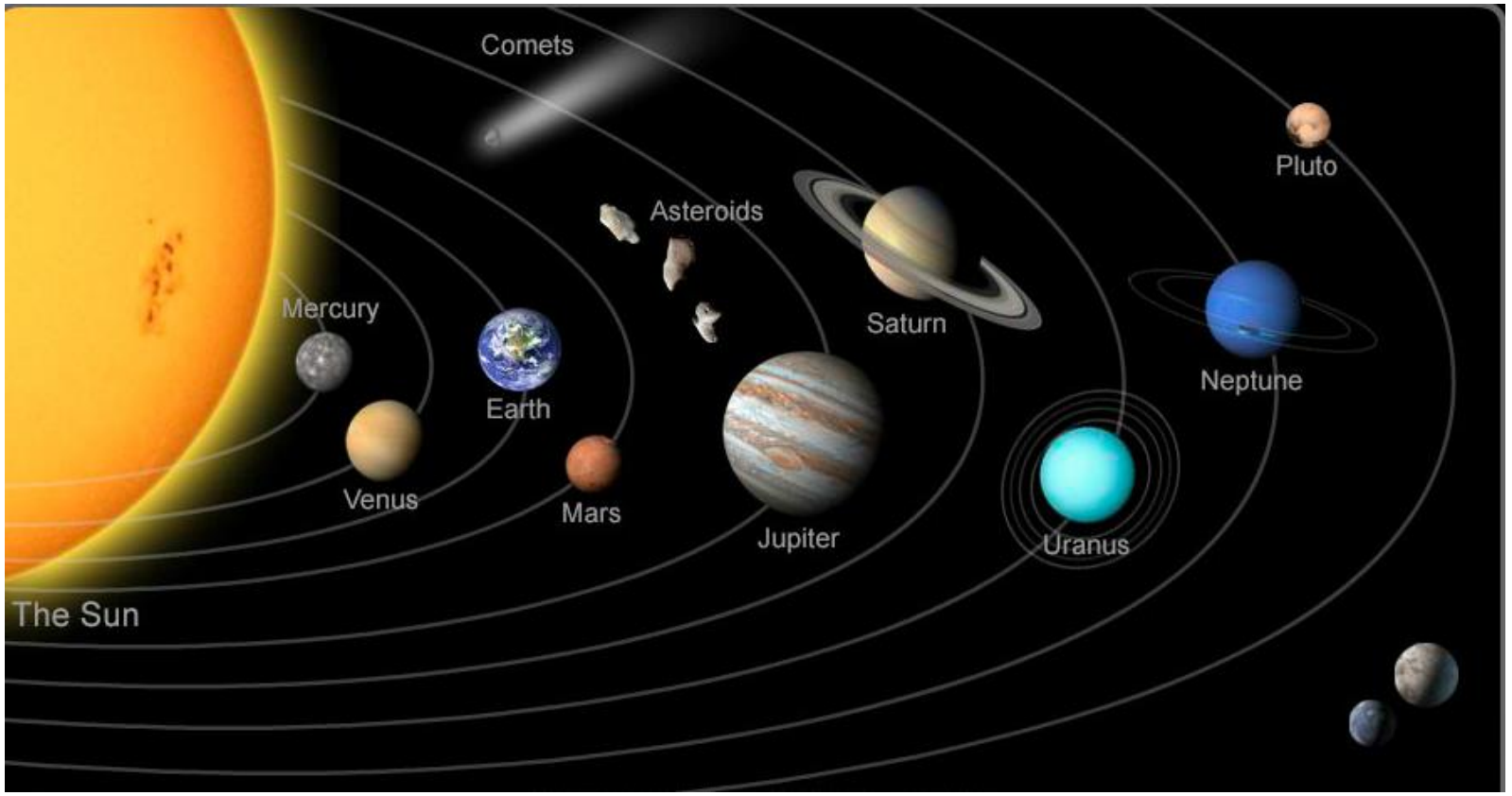
2015 : Do you know Pluto was voted out of the Solar System ? We have 8 planets now.



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A word on the Method of Science

The Scientist :

Sometimes

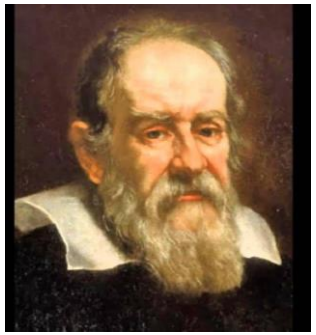
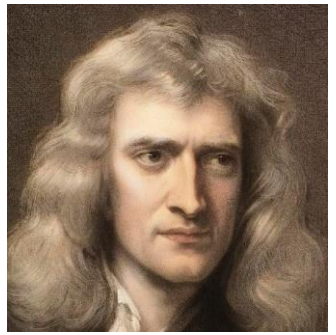
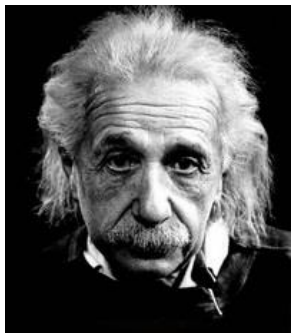
- We have Theory first in the form of :
  Hypothesis, Conjectures, Postulates, Principles or Laws

- Collects data and inspects the data.

A. Miller, *Insights of Genius in Science and Art*, 2000 MIT Press.

Example : Einstein's Special Relativity

1) Principle of Relativity.
2) Principle of the constancy of the speed of light.

Paraphrase :

1) The Laws of physics are the same.
2) The velocity of Light in vacuo is the same.

Sander Bais

Contents:

Choose a Theory : using Occam's Razor

A principle of scientific and philosophical discussion urging the use of the most economical and least complex assumptions terms and theories. It is usually formulated as "Entities should not be multiplied unnecessarily"

a variant of Ockham's Razor

R. P. Feynman, *The Meaning of It All,* 1998, Basic Books.

Contents:

Science a Cultural Activity

I want to stress that physics is a human creative intellectual activity, like art and music. Physics has helped forge our cultural experience. I am not sure what will be most influential in the legacy we pass on, but I am sure that it is a grave mistake to ignore the cultural aspect of our scientific tradition.

In the end, what science does is change the way we think about the world and our place within it. To be scientifically illiterate is to remain essentially uncultured. And the chief virtue of cultural activity, be it art, music, literature, or science - is the way it enriches our lives.

L. M. Krauss, *Fear of Physics*, 2007, Basic Books.

Cultural Examples :

a) The fundamental nuclear particle called Quark comes from Finnegans Wake, by *James Joyce.*

There was a debate if we should use Ace (discussed by another well known Physicist. But quarks won and Nobel prize went to Murray Gell-Mann.

b) Two physicists discovered the J/ψ nuclear particle; neither discoverer want to give up their names. Interestingly it is called J particle because the surname of one of the physicists is Ting (it is a Chinese Character). In this case, there is a happy ending !

Contents:

Popper Philosophy of doing Science

Science is perhaps the only human activity in which errors are systematically criticized and … in time corrected.

Scientific knowledge has turned out to be conjectural, permanently open to revision in the light of human experience. The same principle seems also to apply to politics.

Karl Popper

B. Magee, *The Story of Philosophy*, 2001 Dorling Kindersley Book.

There is No Certainty in Science

Popper realized that if the centuries of corroboration received by Newtonian science had not proved it to be true, nothing was ever going to be prove the truth of a scientific theory. So-called scientific laws were not incorrigible truths about the world after all; they were theories, and as such they were products of the human mind.

If they worked well in their practical application then that meant they must approximate to the truth, yet it was always possible, even after hundreds of years of pragmatic success, for someone to come along with a better theory that was closer still to whatever the truth was.

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Summary : Scientific Theories are not final !

We do not claim that the portrait we are making is the whole truth, only that it is a resemblance.

Victor Hugo,
Le Miserables

http://www.greatdeals.com.sg/2015/11/02/les-miserables-musical-singapore-tickets-sale

Appendix : The Tao of Science (Physics)

Are these Science (Physics) enquiries relevant to students who want to participate fully in our science-technology based culture but who would not necessarily use Science (Physics) in their professional lives ?

- One reason for learning science is to expand awareness.
- Develop social values appropriate to the scientific age.
- To resolve today's problems or moral dilemmas.

  Literate people must also be numerate.

A. Hobson, *Physics, Concpets and Connections*, 2010 Addison-Wesley.