Science

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Science Defined!

Science - a systematic study of nature based on observation.

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Deductive Reasoning

- Perfected by the Greek Philosopher Aristotle
- Begins with a statement called a premise
- The solution is derived from logical statements which comes from a conclusion

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Deductive Reasoning

Example: Geo-centrism

1. The Sun moves in the sky from East to West
2. The spot at which we observe this is stationary
3. Therefore the Sun revolves around the Earth

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The Winds of Change!

- For the next two thousand years science was the domain of the astrologers and Priests.
- Galileo revolutionized the scientific community by introducing a new way.
- Galileo argued that inductive reasoning not deductive reasoning was logical.

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Inductive Reasoning

- First proposed by Galileo
- Collect specific information about a problem
- Draw conclusion based on the data
- Result is probable or most likely

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Inductive Reasoning

1. Hydrochloric acid when mixed with Sodium Hydroxide (base) produces heat, salt and water.
2. Therefore:

   When an any acid is mixed with any base then heat, salt and water is most likely produced.

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What is data?

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Scientific Data ?

- In science we must be able to measure what we see in some way
  - Quantitative data
  - Qualitative data
- All goal of gathering data is to be as objective as possible.

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Quantitative data

- Deals with numbers.
- Data which can be measured.
- Length, height, area, volume, weight, speed, time, temperature, humidity, sound levels, cost, members, ages, etc

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Qualitative data

- Deals with descriptions.
- Data can be observed but not measured.
- Colors, textures, smells, tastes, appearance,etc.

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Latte Comparison

Qualitative	Quantitative
• robust aroma	• 12 ounces of latte
• frothy appearance	• serving temperature is 150º F.
• strong taste	• serving cup is 7 inches in height
• burgundy cup	• the cost is $6.95

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Experimental Research

Hypothesis

A supposition or proposed explanation made on the basis of limited evidence as a starting point for further investigation.

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Experimental Research

Null-hypothesis

- A type of hypothesis that proposes that no statistical significance exists in a set of given observations.
- Hypothesis of "no change"

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Experimental Research

Example

- H_1 If students are given caffeine before a test, then they **will perform better**.
- H_2 If students are given caffeine before a test, then they **will perform worse.**
- H_0 If students are given caffeine before a test there will be **no change in their performance.**

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Experimental Research

Observational study

- The researcher (or student) conducts a laboratory procedure to observe natural phenomenon.
- This is commonly done in the classroom setting to better understand laws and theories.

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Experimental Research

Experiment

- A procedure carried out to support, refute, or validate a hypothesis.
- Demonstrating what outcome occurs when a particular factor is manipulated.
- Rely on repeatable procedure and logical analysis of the results.

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Experimental Research

- Experiments typically include controls, which are designed to minimize the effects of variables other than the single independent variable.
- This increases the reliability of the results, often through a comparison between control measurements and the other measurements.

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Experimental Research

Independent variable

It is a variable that stands alone and isn't changed by the other variables you are trying to measure.

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Experimental Research

Independent variable

A persons age can not be changed by factors such as what they eat, how much they go to school or how much television they watch.

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Experimental Research

Dependent variable

It is something that depends on other factors, and could change because of various forms of manipulation.

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Experimental Research

Dependent Variable

A test score could be a dependent variable because it could change depending on several factors such as how much you studied or how much sleep you got the night before you took the test.

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Scientific Inquiry

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Understanding Science

- Scientific Method relies on observation.
- Observations can be biased.
- Conclusions can be biased
- The scientific method can NOT determine absolute truth!

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ABSOLUTES !

The ONLY absolute in Science is

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Theories, Guesses, Laws

- What does the word "Theory" mean?
  "A conjecture; guess"
  (Webster's Dictionary)
- Does it mean the same to a scientist?
  "A model which has been born out by repeated tests and observation."

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Theories, Guesses, Laws

- Is a Theory less than a Law?
  "Evolution is a theory, it is not a law." A theory is an assumption based on a best guess. (apples vs oranges)
- Do Theories contain Laws?
  In "Einstein's Theory of Relativity" the primary components of this theory have been demonstrated ($E=MC^2$) .

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Observations and Inferences

- All scientists will make the same observations about an event.
- This is because observations are facts and are not open to interpretation.

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Observations and Inferences

- However, scientists can make different inferences of the same event.
- This is because a scientist's current knowledge and perspective affects his/her interpretation.

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Observation vs. Inference Examples

Observations	Inferences
• That plant is extremely wilted.	• That plant is extremely wilted due to a lack of water.
• The car stopped running	• The car stopped running because it was out of gas.
• The Sox are leading their division	• The sox are leading their division because they are playing well right now.

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Note the Differences

- In the laboratory setting, you record observations.
  - It produced heat or gas
  - It changes color
- *NOT* inferences. Inferences represent your conclusion about what occurred.
  - There was a physical change in matter
  - There was a chemical change in matter

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Observation vs Inference

- On the next slide, indicate if the statement is an observation or an inference.

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1. There is a representation of a face on one side of the coin.
2. The Latin word "Dei" means "God."
3. The coin was made by deeply religious people.
4. The date 1722 is printed on one side of the coin.
5. The coin was made in 1722.
6. The face on the coin is a representation of the nation's president.

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Thematic Application Test (TAT)

1. The TAT uses inference to evaluate a person's psychological state.
2. The TAT is like a set of picture cards showing different scenes and situations, like people talking, or someone feeling sad.
3. When someone gets the TAT, they are asked to look at these photos and create stories about them. These stories show how people feel, how they think, and how they relate to other people.

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TAT Example 1

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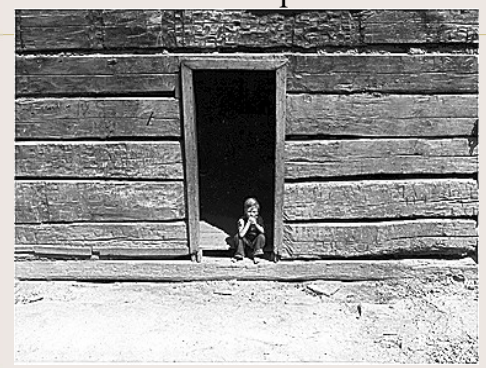
TAT Example 2



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TAT Example 3

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Scientific Laws and Theories

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Scientific Laws and Theories

- Unlike theories, scientific laws are not subject to change

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Scientific Laws and Theories

- Scientific laws are not theories that have been proven true.

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Scientific Laws and Theories

- A scientific law is a description of a relationship or a pattern in nature.

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Scientific Laws and Theories

- A law generalizes a body of observations.
- No exceptions have been found to a law.
- Scientific laws explain things (how), but they do not describe them (why).
- Example:
  - Newton's Law of Gravity. Newton could use this law to predict the behavior of a dropped object, but he couldn't explain why it happened.

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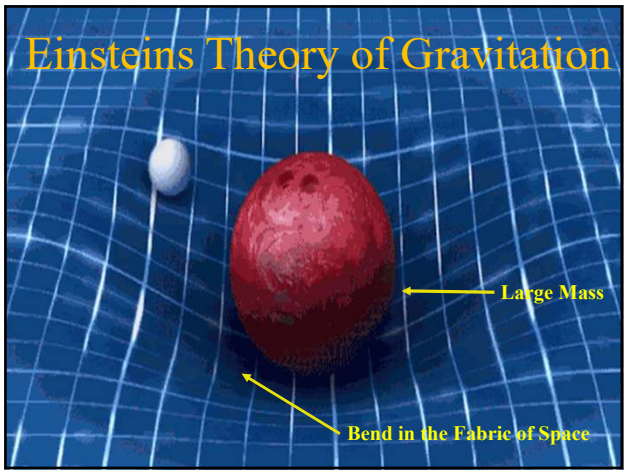
Einsteins Theory of Gravitation



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Scientific Laws and Theories

- A scientific theory provides an explanation for a relationship or pattern in nature.

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Scientific Laws and Theories

- Scientist observe and identify laws.
- Scientists create theories

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Scientific Laws and Theories

- Scientific theories exist to help explain the natural world and are uncovered through scientific investigation.

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Science as a Body of Knowledge

- All scientific knowledge is subject to on going testing and revision

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Science as a Body of Knowledge

- All scientific knowledge can be discarded or changed when new evidence justifies it.

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Science as a Body of Knowledge

- Scientists knowledge can change when scientists re-interpret existing findings.

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Examples of Misconceptions

- ***Carbon dating***
  - **For carbon-14 dating to be accurate, one must assume the rate of decay of carbon-14 has remained constant over the years.**
  - **Evidence indicates that the opposite is true. Experiments have been performed using the radioactive isotopes of uranium-238 and iron-57, and have shown that rates can and do vary.**
  - **Changing the environments surrounding the samples can alter decay rates**
- ***Beneficial mutation***
  - **The known examples of beneficial mutation exist only at the microscopic level.**
  - **Adaptation to High and Low Temperatures by E. coli**
  - **Adaptation to Growth in the Dark by Chlamydomonas.**
  - **Adaptation of yeast to a glucose limited environment via gene duplications and natural selection.**

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Repeatability

- A successful theory is repeatable.
  - –By you.
  - –By anyone.

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Non-scientific Theories

- Make no predictions
- Un-testable
- Can't be falsified (proven to be un-true)

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Non-scientific Theories

- The chain of events needed for life to arise on earth is too complicated to have happened by chance, an alien intelligence must therefore have caused life to arise.
- Proof - Face on Mars.

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Non-scientific Theories

Viking Orbiter (1976)

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Non-scientific Theories

Mars Global Surveyor (1998)

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False Sciences

- Phenomenon - no provable basis for an event or theory
- Pseudoscience- appears as scientific truth but is not testable
  - (example: phrenology or skull shape predicts intelligence)

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Confirmation Bias

- A tendency for people to favor information that confirms their preconceptions or hypotheses regardless of whether the information is true.
- As a result, people gather evidence and recall information from memory selectively, and interpret it in a biased way

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Examples

- Sally is in support of gun control. She seeks out news stories and opinion pieces that reaffirm the need for limitations on gun ownership. When she hears stories about shootings in the media, she interprets them in a way that supports her existing beliefs.
- Henry,is adamantly opposed to gun control. He seeks out news sources that are aligned with his position, and when he comes across news stories about shootings, he interprets them in a way that supports his current point of view.

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True Science

- Objectivity - determined by examination and without bias
- Reproducible: All results can be demonstrated by any individual following the same process or procedure

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True Science

- Falsifiable - theory can be proven wrong by new information
- Observable - can be measured or described either directly or indirectly.

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Limitations of Science

- If it can not be tested, it can not be probable or most likely
- Pure objectivity is difficult to obtain
- It must be able to be expressed in some form of mathematical relationships

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Paradigms

- Particular view or bias
- Basis for the way we perceive ourselves and our world.
- There are different types of paradigms

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Paradigm Examples

- Evolutionary Paradigm
- Intelligent Design Paradigm

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Evolutionary Paradigm

- All life came from inert matter
- The physical universe is a result of natural evolutionary process
- Man is an accident of nature
- There is nothing beyond our finite reality

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Scientists that believed in a Evolutional paradigm

- **Charles Darwin (1809-1882)**
  Primary contributor to the theory of evolution and natural selection
- **Richard Feynman, (1918-1988)**
  Developed the theory of quantum electrodynamics and the physics of super fluidity.
- **Steven Weinberg (1933)**
  Discovered electro-weak forces in relation to electromagnetism
- **Francis Crick (1916-2004)**
  Discovered the structure of the DNA molecule
- **Carl Sagan (1934-1996)**
  Pioneered exobiology, authority on astronomy and astrophysics

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Intelligent Design Paradigm

- There is a Supreme intelligent being(s).
- He is the creator of all things
- He makes known to us the basis for all understanding about him, creation, the earth and our purpose in life.

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Scientists that Believed in a Intelligent Design Paradigm

- **Nicholas Copernicus (1473-1543)**
  Put forward the first mathematically based system of planets going around the sun.
- **Sir Fancis Bacon (1561-1627)**
  Establishing the scientific method of inquiry based on experimentation and inductive reasoning.
- **Galileo Galilei (1564-1642)**
  Controversial theory on the solar system.
- **Isaac Newton (1642-1727)**
  Genius and innovator in optics, mechanics, and mathematics.
- **Gregor Mendel (1822-1884)**
  Developed the mathematical foundations of genetics.
- **Robert Boyle (1791-1867)**
  Groundbreaking work on the understanding of gases

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REMEMBER!

A true scientific process does not have to be affected by paradigms !

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"The Principle of Limited Sloppiness"

Fortuitous or accidental discoveries – events which occurred inadvertently but were recognized as discovery by the scientist(s) involved.

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Accidental discoveries

- Alexander Fleming noticed that a mold had contaminated his flu cultures in the lab.
- This was attributed to his lab assistant eating a sandwich while preparing the cultures. Particles of bread fell into the cultures which provided a medium for the mold growth.
- He realized that the area around the mold was clear of infection. He received a Nobel Prize for discovering Penicillin

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Accidental discoveries

- Swiss engineer Georges de Mestral found burrs clinging to his pants and also to his dog's fur during a hike in the mountains.
- On closer inspection, he found that the burr's hooks would cling to anything loop-shaped like woven material or matted hair.
- He then artificially re-created the hook and loop system, the result was Velcro.

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Accidental discoveries

- Constantin Fahlberg, after a hard day of working with coal tar, came home and, without washing his hands, grabbed one of his wife's dinner rolls and bit into it.
- It tasted sweet. He asked his wife if she had been doing anything different with the rolls. She hadn't.
- Fahlberg had discovered saccharine (Sweet and low) ,

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Accidental discoveries

- John Pemberton, a pharmacist, just wanted to cure headaches. Pemberton used two main ingredients in his hopeful headache cure: coca leaves and cola nuts.
- When his lab assistant accidentally mixed the two with carbonated water instead of regular water, the world's first Coke was the result.

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Branches of Chemistry!

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Chemistry Major Branches

Inorganic

Study of all elements other than carbon and their compositions.

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Chemistry Major Branches

Organic

Study of all elements containing carbon.

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Chemistry Major Branches

Biochemistry

Study of the chemical process in living things.

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Chemistry Major Branches

Nuclear

Study of radioactivity, the nucleus and the changes that the nucleus undergoes.

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Vocational Chemistry

Pure Science

Scientific knowledge for the sake of finding out new facts about matter

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Vocational Chemistry

Applied Science

Scientific knowledge for the sake of creating useful products.

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