What is Science?

Many people think of science as a bunch of facts, a giant dictionary

but it is more: a **process**, a way of looking at the world; **a way of uncovering knowledge**

there are many ways to uncover knowledge and to better understand our world and ourselves:

> music
> art
> poetry
> philosophy
> theology
> history
> scientific investigation
> etc

> each these disciplines can provide valid information

> all teach us something important

but each addresses different questions or different aspects of a question

> eg. science can show us how to clone animals & plants, how to improve crops, how to produce stem cells, etc

> eg. philosophy & religion can highlight the moral and ethical implications of those advances and help us to decide whether we should really be doing these things or not, whether we have a right to do them

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> eg. politics, government tells us how we can make fair laws to protect all who are faced with such difficult decisions

> eg. music and art can help to express our emotional connections to the world

all are just different **languages** or ways to describe the world

science is **one** process of understanding how the world works

science is a **language**, a **tool,** a method for searching for knowledge

> (but only one of many sources of knowledge)

we use them all and need them all to produce a well rounded understanding or our world

Each method of describing the world requires that we follow a specific set of **assumptions** or criteria:

> music → tonal qualities, tempos, harmonies

> art → mix of colors, lines, perspective, depth

> philosophy → criteria of logic, inductive and deductive reasoning

> eg flower, a sunset, our "place" in the world

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to use **scientific methods** correctly we must make certain assumptions and follow certain rules

> otherwise we are NOT "doing science"

1. explanations must be guided by <u>**Natural** Laws</u>

> the world works as a natural **machine**

>> **mechanism** (Descarte, 17th century)

>> mechanistic view →no "vital spirits"

>> **reductionism:** complex processes can be reduced to simpler components

> In science, we assume that everything is **reducible** to simple understandable natural explanations:

>> body functions
>> smile of a baby
>> even a persons philosophical and religious beliefs (eg temporal lobe seizures)

> there is no room in science for magic or supernatural

>> eg. life or health is not the result of "vital forces"

>> eg. "creation science" is an oxymoron

>> eg. "intelligent design" assumes unnatural or supernatural forces control the universe, it is therefore not a scientific concept

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2. explanations must be **falsifiable**

> scientists begin by making **hypotheses** (=educated guesses) about what is going on

> scientific hypotheses are not necessarily more likely to be true

> but it must be able to be **disproven** or its not a *scientific* explanation

>> eg. observation: my car wont start

>>> possible hypotheses:
>>> battery is dead
>>> out of gas
>>> aliens zapped car with an energy sucking ray

>>> the last one is NOT a scientific hypothesis

> statements below are NOT valid subjects of scientific investigation because they cannot be disproven

>> eg. your neighbor insists that he was abducted by aliens

>> eg. a friend believes that her astrological sign accurately describes her personality or future events

>> eg. the belief that "God created the universe"

> all explanations must be testable by

experimentation

an experiment is essentially an attempt to disprove your hypothesis

eg. virtually ALL strides in medical treatments have come from scientific knowledge

→ from testing and retesting various hypotheses or explanations

almost all rigorous testing of alternative medical practices have shown them to be ineffective

3. the process of science **requires** logical reasoning

"human nature" generally tends to cause most people to actually form an opinion first and then collect information that seems to support or make sense of the idea

eg. there are today people who firmly believe that the earth is flat or that it is only 6000 years old despite massive amounts of data that disprove thess concepts

eg. politics: we tend to like or hate someone and see all that happens through that lens. So much so that we essentially dehumanize that person, and its often hard to resist even when we know better

experimentation requires careful **unbiased observations**

→ can't set out to "prove" something

eg. if you already believe in bigfoot or flying saucers you are biased and cannot make very effective *scientific* observations

eg. Loch Ness assumes something is there then builds elaborate theory to "explain" data or lack of data

eg. Bermuda Triangle
percentage of vessels lost in triangle are no higher than anywhere else
but percentage of false losses are much higher for this area

it is very difficult, even for scientists to eliminate bias; to keep an open mind

a. one way to reduce bias is that the same observation must be **repeatable** by others

eg. one (or a few) persons claim of UFO or abduction is not a scientific observation

→ testamonials are not scientific data

when many people see the same UFO and their observations are unrelated in any way and can produce unambiguous physical evidence then UFO's will be accepted as scientific fact

b. in designing an experiment it is best to pose question (hypothesis) as an "either/or" statement

a given question may have 1000's of logical answers but only one is correct,

therefore the chances are high that a random guess will be wrong

eg. observation: my car wont start

hypotheses: battery is dead
wiring is fried
out of gas
someone stole the distributor cap

must choose each one at a time and test it until you

c. experiments must be rigorously **controlled**

→ but must be aware of your assumptions

4. statistical analysis is a powerful tool to sort through large numbers of observations (data) and likely conclusions

but must be used correctly; one can lie with statistical methods that are misused

eg. from huge amounts of data collected we can logically conclude that consumption of pickles is dangerous & can cause:
cancer
war
communism
auto accidents

data:
those born in 1839 who ate pickles have sufferend 100% mortality rate
rats force fed 20 lbs of pickles a day for a month ended up with bulging abdomens, poor health and loss of appetite
99.9% of cancer victims had eaten pickles sometimes in their lives
100% of all soldiers
96.8% of communist sympathizers
99.7% of those involved in car accidents

5. the simplest logical explanation is the preferred one (=Occam's Razor)

Extraordinary hypotheses require extraordinary evidence

eg bigfoot, ufo's, astrology, etc

6. scientific explanations must have **predictive value**

eg. if an apple falls to the ground today, you can predict that it will do so tomorrow and the day after

the scientific method is a **self-correcting** process

it is the ONLY source of knowledge that is self correcting

scientists think like everyone else but with more awareness of the possibility that they may be wrong!

versus a politician who must act like he can never be wrong

or theologian who accepts a concept on faith alone, with no experimentation

7. the strongest explanations that have survived numerous attempts to disprove them become **theories**

A theory is an hypothesis that has been repeatedly verified, not disproven

the word "Theory" in general use is used for any idea someone has on a topic; a hunch

in science an **hypothesis** is a "hunch"

a **theory** is an hypothesis that has been repeatedly tested, 1000's of times, in many different ways by many different people and the results always support the hypothesis; never disprove it.

we sometimes hear the rationalization for not valuing a scientific theory that "its *just* **a theory**"

but then;

its *just a theory* that the sun rises every morning

its *just a theory* that the heart pumps blood in the body

its *just a theory* that penicillin can be used to effectively treat some bacterial infections

theories are **not** speculation

→they are supported by massive amount of evidence

a theory is a scientific fact

its as close to the truth as a scientist can get

but we haven't "proven" a thing

→**nothing has been (is ever) proven** in science

but only need one disproof

theories do not last indefinitely

most theories have a very short life span as originally proposed

→ they are only **temporary truths**

few survive more than a couple of years without being revised or discarded

as more and more tests are done the theory is revised, remolded, "tweaked" to be even more precise and more accurate

but only rarely does the entire theory get discarded

eg. spontaneous generation

eg. earth centric solar system

they don't necessarily become incorrect, just obsolete for some situations

as theories are refined they become more inclusive and are able to make stronger predictions

replacing a theory that is wrong with one that is more "subtly wrong"

eg. "theory of agriculture"

seed sprouts
seed sprouts better with water
seed sprouts better under soil with water
add manure
prevent disease
root nodules
mycorrhizae
etc.

as theory is refined it becomes more and more accurate at predicting future events

eg. Heredity
something in cell transmits traits to offspring (Mendel)
it is in nucleus
it is in chromosomes
its either proteins or DNA
its DNA
specific genes identified

when we find exceptions to a current theory we

are usually discovering new factors that might influence a particular outcome

sometimes a theory becomes so powerful at predicting that it becomes a natural law

→implies there are NO exceptions

eg. an apple always falls to the ground until the '50's anyway

→ one exception even a "law" must be altered or trashed

eg. "Law of Gravity" became just a small part of a more complete "Theory of Relativity"

Science can never explain everything

only those things that can be investigated using correct assumptions

eg. science will never be able to:

define right and wrong?
why we are here?
is there life after death?
is there a "god"

these are not scientific questions

they are best studied in other disciplines