

A. Epistemology — the study of ways of knowing

1. many different forms of human knowledge, each with different rules for truth
2. examples: theology (religion), law, art, science

a. in religion, truth is handed down, it is unquestionable to believers, and absolute.

There are many different religions, because there are many different revealers. The supernatural is usually not excluded; i.e. miracles are allowed (miracle = an event that generally only happens once, and is outside the range of normal experience). Believers have faith in their belief — faith is the ability to believe in spite of lack of "scientific" evidence or evidence to the contrary. Those who need "reasons" (scientific evidence or some other kind of evidence) for their belief have weak faith. Religious belief is not a matter of evidence, it is a matter of faith.

b. in law, it is supposed to be what are the minimal rules necessary for society to function to the satisfaction of the people in the society. Laws are supposed, at least in Western tradition, to be minimalist, fair, and equally applied. In law (not necessarily justice mind you — at least the name of the courthouse complex in Rancho Cucamonga reflects this: "Foothill Communities Law **and** Justice Center" - emphasis mine), 12 local yokels, who know nothing about law (such as your instructor), are drafted off the street, subjected to various questions by a bunch of well, I guess the polite term is "lawyers", and those who seem to know anything about the subject are often made to leave. The rest are then asked to make what are possibly life and death decisions after having been spoon-fed a very selective portion of what passes for "evidence" in law. Jurors are not usually even allowed to ask questions, but are treated more like mushrooms. Law also doesn't seem to take "I don't know" for an answer: a person must be found guilty or not guilty — if the jury "hangs" (meaning, essentially, a verdict of "We don't know"), the case is often retried.

Aren't you glad medical decisions about your own health care aren't made by 12 people off the street who know nothing about medicine? Especially if they have been smooth-talked by someone peddling a quack medicine, when the medical side was perhaps represented by a scientist who perhaps wasn't as glib of tongue?

In science, on the other hand, there is no such thing as "suppression of evidence" — all relevant evidence is considered (mind you, some things are irrelevant, such as someone claiming to violate the law of entropy in a closed system. This is simply irrelevant because the amount of evidence for entropy is overwhelming. It is possible that the laws of thermodynamics are wrong for objects not as yet well-studied, and that someone will someday prove the laws of thermodynamics to be a subset of still more fundamental laws). Scientific questions are answered by a consensus of expert scientists — or not answered, as the case may be. Although scientists like answers as well as anyone, we also realize that for many questions, there are simply not enough data to decide. Also, part of the fun of science is making up hypotheses — once the answer is known, one no longer has any fun arguing about the subject with one's colleagues.

What constitutes scientific truth changes as more evidence is brought to bear on the question — this is unsettling to some people, who want absolute truth. In science, however, we simply hope to get an ever closer approximation to some underlying objective truth. Scientists continually challenge each other, because only by such a give and take is truth most likely decided. In law, there is a somewhat similar give-and-take between lawyers on opposing sides, but not all evidence is considered, and then the decision is left to 12 people as non-expert as the lawyers can generally find.

- c. in art and music, not truth, but beauty is the standard by which works are judged. Among other things, the evocation of a strong emotional response is the aim of good art. Different people's emotions respond to different things; the phrase "I may not know art, but I know what I like" is the essence of fine art — your emotions may not be in sync with those of a given art critic, but a certain piece of art or music may, in fact, evoke your emotional response, so to you, it is a good piece of art or music.
- d. science = **natural** science, i.e. the supernatural is excluded. Miracles may in fact occur, but they are not part of science. Natural phenomena are the province of study of science. Of course, people's definitions of what are natural phenomena may differ. Science attempts to derive tested explanations for repeated observations. Observations become science when they have tested, natural explanations. The essence of science, therefore, is to derive mechanistic (= natural) explanations for observations that have are repeatable.

B. Science as a way of knowing.

1. Science does not always proceed by the simple "scientific method" so popular with public school textbooks.
2. Scientific terminology is different from the lay use of the terms. "Hypothesis", for instance, is a term used to signify a carefully thought-out and perhaps preliminarily tested explanation for a natural phenomenon. A "Theory" in science is a very well tested explanation — it might be the wrong explanation, but there is a lot of evidence in support of a theory. "Theories" in science are not to be dismissed with the phrase "Oh, well, its just a theory." In science, theories are not "just" theories, i.e. not just wild guesses. Scientific "laws" or "facts" are explanations (laws) or observations (facts) that have so much evidentiary support that they are almost assuredly correct, at least with the current basis of science.
3. Science does not yield absolute truth = "TRVTH". There is almost always either some doubt or some deeper explanation for phenomena currently explained by various scientific theories or laws. In science, we attempt to find ever closer approximations to "TRVTH", but we may never find any "final" answers.

D. Empirical Science

1. Traits that distinguish empirical science from common knowledge
example: Children resemble their parents more than other adults
 - a. science seeks the systematic organization of knowledge

- b. science seeks mechanistic explanations (the WHY) of observations
- c. how is genetics different from common knowledge statement above?
 - (1) (organization of genetics; combining gen. with physiology, anatomy, etc.)
 - (2) (genes are passed on, genes determine traits, DNA encodes genes etc.)
- 2. Criterion of demarcation — the criterion that marks off science from other areas of study
 - a. empirical falsification — a scientific hypothesis must be, at least in principle, falsifiable. This testing marks science as different from other knowledge.
 - b. it is possible to show the falsity of a universal statement, but not its truth
 - (1) for example, "all trees have leaves". The next tree might not have leaves, so it is in principle falsifiable unless it is a tautology (using leaves to define "tree") However, one cannot examine all trees that have ever lived, are living or will in the future live, so one cannot "prove" the statement. However, one can gather immense amounts of corroboration, i.e. support for the theory. Theories can be well-supported, can even have NO counter-examples, but cannot be absolutely "proven".
- 3. Science is a complex enterprise that consists of two interdependent episodes:
 - a. the creative exercise of advancing a hypothesis — incentive for doing science
 - b. critical exercise of examination & empirical testing—must be done, even if boring
- 4. Forming hypotheses — a hypothesis must meet these criteria to be scientific
 - a. it must be internally consistent (cannot be self-contradictory or not logically well-formed)
 - b. it must have explanatory value — does it actually explain observations? it cannot be purely tautological (going in circles) (if plants are defined as organisms having leaves, you cannot test whether having leaves makes it a plant)
 - c. the hypothesis should be consistent with known existing information unless you think you can upset the whole apple cart with your hypothesis — this does happen occasionally, as when quantum theory replaced Newtonian theory, or when continental drift changed most of geology.
 - d. the hypotheses must be able to be tested empirically. You must be able to derive predictions, which are at least in principle falsifiable, from the hypothesis
- 5. Testing hypotheses
 - a. again, can show falsity, but can't "prove" hypotheses
 - b. Type I error: rejecting a true hypothesis

- c. Type II error: accepting a false hypothesis — 1-this (ability to reject a false hypothesis) is the POWER of a test
 - d. increase power by repetition and large sample sizes
 - e. the larger the number of potential falsification tests, the greater the power
 - f. the more precise the prediction from the hypothesis, the more severe the test
 - g. critical test: experiment for which competing hypotheses predict alternative, mutually exclusive outcomes
 - h. process of testing subject to human error, bias, and dishonesty
 - i. prediction must be logical consequence of hypothesis
6. Mendel's paper good example : 1st half is hypothesis, 2nd half is testing
- E. In evolution, two kinds of questions
- 1. historical questions — the actual course of evolution on earth
 - 2. mechanism questions — how and why did change occur (causal questions-what caused?)
- F. Emergent properties of complex systems and reductionism
- 1. can the course of evolution be predicted from physical law?
 - 2. complex systems by their very complexity have properties that are not necessary consequences of their physical parts — emergent properties
 - 3. complex systems are very sensitive to initial conditions
 - 4. are water, alcohol, proteins and humans inherent properties of hydrogen? Does the structure of a hydrogen atom help in understanding what it takes to make a human? Well, a little bit, maybe, but how much?
 - 5. Reductionism — study of complex objects by studying their simpler components
 - 6. holism — attempts to understand complex objects as wholes
 - 7. nobody can answer "can the course of evolution be predicted from physical law?"
"at this time"