Announcements and Such

- Two Songs — *Cymande*
  - "Losin Ground", and
  - "The Recluse"
  - …both from *Promised Heights*
- **Second Essay due today** @ 4pm
- **Today:** *Scientific Knowledge*
  - (Mainly) *Individual* Scientific Knowledge
  - (Briefly) *Social Aspects* of Scientific Knowledge
- **Next Time:** *Moral Knowledge*

Scientific Knowledge I
The Objects of Scientific Knowledge I

- Scientific knowledge depends very heavily on *perception*, because it involves *empirical* claims.
- But, science is not so much concerned with claims about *individual* physical objects (*particulars*).
- Science is concerned with *general* claims about physical objects, which are called *laws of nature.*
- Some historical examples of laws of nature are:
  - Kepler's laws of planetary motion
  - Newton's laws of motion
  - Einstein's laws of relativistic motion
- These are all claims about physical objects, but they are *not* claims about *particular* objects.
- And, *not all true general (physical) claims are **laws**.*

Scientific Knowledge I
The Objects of Scientific Knowledge II

- Consider the following two claims:
  1. All man-made macroscopic objects have a maximum speed of <11,500 meters per second.
  2. All man-made macroscopic objects have a maximum speed of <300,000 meters per second.
- Claim (1) is a true general claim about the (actual) physical world. Thus, so is (2). But, (2) is *different*.
- One key difference between (1) and (2) is that (1) is *not **implied** by* our best physical theories, but (2) *is*.
- (1) *happens to* be true, but it is *consistent* with our best physical theories that claim (1) be *false*.
- (2) *must* be true, *if* our best scientific theories are true. This makes (2) a *law of nature*, whereas (1) is merely a (actually) true general (physical) claim.

Scientific Knowledge I
The Objects of Scientific Knowledge III

- Of course, we can *use* scientific theories to *predict* things about *particular* objects. This typically requires the use of *auxiliary assumptions*.
- For instance, we can *use* Newton's laws to *predict* the trajectory of a *particular* spacecraft. But, to do this, we need to plug-in various *auxiliaries*.
- In this case, the auxiliaries might include the *initial velocity*, *position,* and *mass* of the spacecraft, *etc*.
- Also, some "laws" can be *derived* from *more general* "laws" with the help of *auxiliaries*.
  - We can *derive* Kepler's "laws" of planetary motion from Newton's "laws" of motion, by plugging-in the appropriate auxiliaries (the masses of the planets and their initial velocities)
- Science is after the *most explanatory set* of laws.

Scientific Knowledge II
The Nature of Scientific Discovery I

- Science operates *via conjectures* and *tests*:
  - First, a *question* (of a general nature) is posed. [Usually, these questions arise because some *unexplained phenomena* have been observed.]
  - Then, (and sometimes simultaneously) various *candidate answers* (*hypotheses*) are formulated.
  - Finally, *tests* (*experiments*) may be performed, which, *given background assumptions* (*auxiliaries*!), are capable of generating *evidence*.
  - It is important that the experiment(s) be able to *discriminate* (some of) the candidate hypotheses.
  - Each of the competing hypotheses (+ auxiliaries!) will have *consequences* (that are deductively or statistically *incompatible* with those of other H+A's) that the experiment is designed to test.

Scientific Knowledge II
The Nature of Scientific Discovery II

- This methodology of scientific inquiry is sometimes called *inference to the best explanation*.
- We begin with some phenomenon that isn't (adequately) explained by our current theories.
- We then formulate various alternative candidate explanations of this phenomenon.
- Finally, we *infer* that the theory which *best explains* the phenomenon (***all** known* phenomena) is true.
- Note: this does *not* result in a "proof" of the most explanatory theory. This is merely *evidence* which *favors* one theory over *some* alternative theories.
- There may still be an *even better theory* out there that has not yet been imagined and/or tested…
- In this sense, "scientific inference" is *inductive* and *fallible*, and *only as good as the auxiliaries it uses*.

Scientific Knowledge II
The Nature of Scientific Discovery III

- Duhem/Quine warned that "disconfirmation" by an experiment, is sometimes to be blamed on the *theory*, and sometimes on the *auxiliaries* used.
  - Example #1: before Neptune was discovered (1820's), an *unexplained wobble* in the orbit of Uranus was observed. They conjectured this was *not* a problem with *Newton's theory*, but with an *auxiliary assumption* about the number of planets. They were right — Neptune was observed in 1846.
  - Example #2: later (1859), an *unexplained wobble* was discovered in the orbit of Mercury. Again, it was conjectured that an *as yet unseen* body exists, and that Newton's theory was *not* to blame for the prediction. This time, *the auxiliaries were OK* (no such body was discovered)! This crucial experiment *favors* Einstein's theory *over* Newton's.
- Sometimes auxiliaries are to blame, sometimes not.

Scientific Knowledge III
Fallibilism and Approximation in Science I

- **Scientific Realism** says that our best scientific theories are true (and "scientists *know* this"). [Scientific knowledge is a set of beliefs of precisely formulated and strictly true generalizations, arrived at by inductive transmission of knowledge from its basic sources in experience and reason.]
- Two fundamental challenges for Scientific Realism arise from *fallibilism* and *approximation*.
- One way to see the challenge here is to think about what is called the *pessimistic meta-induction* (PMA)
  - (PMA) Throughout history, all of our best scientific theories have proven to be *false*. So, the reasonable inductive inference to draw is that our *current* best scientific theories are *also false*.
- Most scientists concede *fallibility* here, but then how can *scientific realism* make any sense?

Scientific Knowledge III
Fallibilism and Approximation in Science II

- It's hard to say that science has made progress by going from *false* theories to *true* theories, since *all* the theories have turned out to be *false* in the end.
- And, since the theories were *false*, nobody could have *known* that they were true. As such, what kind of *scientific knowledge* could there be here?
- Realists want *something objective* that will capture *some* sense in which science is making *progress*.
- Perhaps realists can retreat to "approximate truth".
- If it could be shown that science is giving us theories that are progressively "closer to the truth", then maybe this is *close enough* for realism?
- How are we to *understand* "approximate truth" from both *metaphysical* and *epistemic* points of view? This is a crucial question in Phil. Of Sci.

Scientific Knowledge III
Fallibilism and Approximation in Science III

- Let's bracket the *metaphysics* of "approximate truth" for now, and focus on *epistemic* questions.
- There are two epistemic approaches one can take:
- **Approximate Knowledge**: scientists have well-grounded beliefs, which hold true up to a certain level of precision in measurement.
  - Example: NASA scientists' Newtonian beliefs are well-grounded and they hold true up to a certain level of precision in measurement. They don't hold up under super-high precision, but they are "close enough" to use for launching spacecraft.
- Note: This approach does *not* say (*e.g.*) Newton's *theory* is *approximately true* (although, the next approach *does*). It just says that NASA scientists' *beliefs based on* Newton's theory are *well-grounded and they hold true up to a certain precision*.

Scientific Knowledge III
Fallibilism and Approximation in Science IV

- 2nd Approach: **Knowledge of an Approximate Truth**. Scientists have *knowledge that* our best current scientific theories are *approximately true*.
- Now, we must say what it *means* for a *theory* to be *approximately true*. This seems to require some conception of *verisimilitude* (*closeness to the truth*):
  - The theory is *true in a restricted domain*.
    - This doesn't seem promising, since the *restricted domain* will usually be *idealized* and *ad hoc*. Also, *laws* are supposed to be *universal*.
  - The theory is "close to the truth" along some set and range of of *parameters* that it predicts.
    - This seems OK (as far as it goes), but now things depend heavily on *how one measures* "closeness", and *how one parameterizes*.

Scientific Knowledge III
Fallibilism and Approximation in Science V

- It's surprisingly difficult to give non-trivial, *objective* measures of "closeness to truth" that do *not* depend on *how the phenomena are described*.
- Popper offered a simple account— roughly:
  - T1 is closer to the truth than T2 iff
    - T1 has all the true consequences T2 has.
    - T1 has fewer false consequences than T2 does.
- Miller showed that Popper's account is a failure:
  - According to Popper's account, no false T1 can be closer to the truth than any other false T2.
- This *defeats the purpose* of "closeness to truth"!
- Others have tried to fix Popper's account, but to not much avail. *E.g.*, Tichy and others proposed:

Scientific Knowledge III
Fallibilism and Approximation in Science VI

- Think of theories T1 and T2 as big conjunctions, then "count the number of false conjuncts" (where both theories have same basic vocabulary — *i.e.*, the same set of basic statements, *etc.*)
  - T1 is closer to the truth than T2 iff T1 contains a smaller number of false conjuncts than T2.
- This *can* avoid Popper's problem. But, it faces another one — *language/description dependence*:
  - For any set of questions/parameters and any two false theories, the ordering of which theory is closer to the truth depends on *the language in which the questions/theories are expressed*.
- This can be illustrated with a simple example.
- Suppose that the weather outside is hot (h) or cold (~h), rainy (r) or dry (~r), windy (w) or calm (~w).

Scientific Knowledge III
Fallibilism and Approximation in Science VII

- Suppose the truth is that its hot, rainy, and windy:
  - TRUTH = h & r & w
- Consider 2 competing theories about the weather:
  - T1 = ~h & r & w, and T2 = ~h & ~r & ~w
- T1 *seems* closer to TRUTH than T2, since T1 has only one false conjunct, whereas T2 has three.
- But, instead of describing the weather in the {h,r,w} language, we could use the {h,m,a} language, where
  - m = h ≡ r; a = h ≡ w [so: r = h ≡ m; w = h ≡ a]
- In the *expressively equivalent* {h,m,a} language:
  - TRUTH = h & m & a
  - T1 = ~h & ~m & ~a, and T2 = ~h & m & a

Scientific Knowledge III
Fallibilism and Approximation in Science VIII

- This yields a *trilemma* (see Forster link on website)

1. Abandon the thesis that one false theory can be closer to the truth than another.

- Option (1) is tantamount to *giving up on Realism*.

2. Embrace the idea that verisimilitude *depends on our language*, and therefore embrace a form of *relativism*. [Again, this abandons realism, since it yields *no objective sense of scientific progress*.]
3. Explain why we should regard one particular language/representation as "privileged."

- Option (3) represents a kind of *cultural chauvinism*. *Our* representations/languages are better than *yours* (more on the *social* aspect below)
- A 4th option: (4) deny that there is an *absolute* notion of "closeness to the truth" (verisimilitude).

Scientific Knowledge III
Fallibilism and Approximation in Science IX

- (4) says there is no such thing as *the* verisimilitude of a theory. Verisimilitude is relative to a particular set of questions and a formula for weighing the relative importance of those questions.
- On this view, we'll only get the conclusion that (*e.g.*) Einstein's theory is closer to the truth than Newton's *relative to the questions scientists were asking at the time the two theories were tested*.
- *This* is still *objectively true*, even though *the questions* themselves were determined *socially*.
- Thus, in the verisimilitude literature we see a *subtle* kind of *social dimension* of science.
- The questions *we* (*i.e.*, the scientific community, and the broader community) ask about the world *are chosen by us*. But, *we can agree* on which theories give better answers *to those questions*.

Scientific Knowledge IV
Social Dimensions of Scientific Knowledge I

- Scientific knowledge is *clearly*:
  - Socially sharable
    - We say "science tells us *p*" or "we" know *p*. Thus, scientific knowledge is *social* and *virtual*.
  - Publicly accessible
    - It's important that things we call "scientific knowledge" are *accessible* by a community
  - Cooperatively generated
    - Science involves *lots of teamwork*.
  - Inter-Subjectively Reproducible/Testable/Acceptable
    - Experiments must be reproducible by others, and auxiliaries must be accepted by all involved
- These are *obvious* ways in which SK is *social*.

Scientific Knowledge IV
Social Dimensions of Scientific Knowledge II

- BUT, science is *not* a *naive*, *simple democracy*.
- To see why, consider the *doctrinal paradox*.
  - Imagine that three (or more) scientists *vote* on whether certain scientific claims are true. If there is any logical dependence between the claims, then a *majority rule* can *introduce inconsistency*:

	p	$p \supset q$	q
S1	Yes	Yes	Yes
S2	Yes	No	No
S3	No	Yes	No
Majority	Yes	Yes	No

Scientific Knowledge IV
Social Dimensions of Scientific Knowledge III

- The doctrinal paradox shows that *aggregating* or *combining* (justified) beliefs of multiple agents cannot be achieved by *simple majority* voting.
- If we require *unanimity*, then we can combine without paradox, but this is a *strict* requirement.
- Perhaps we could go for some "super-majority" rule. This is advocated by Pettit, List, and others.
- In any case, what this shows is that when we talk about "(social) scientific knowledge", we are talking about some *subtle* kind of *aggregate* judgment.
- There is a lot of literature lately on these sorts of "social epistemology" questions.
- Search for "judgment aggregation", "social epistemology" and "feminist epistemology" (which gets more into the socio-*political* structure of SK)