05. Inventing Temperature: Chaps 5, 6.

1. Foundationalism *vs.* Coherentism.

Basic Problem: "Empirical science requires observations based on theories, but empiricist philosophy demands that those theories should be justified by observations. And it is in the context of quantitative measurement, where the justification needs to be made most precisely, that the problem of circularity emerges with utmost and unequivocal clarity." (Chang, pg. 221.)

Examples: Justification for

- Standards for constant temperatures.
- Standards for different types of thermometers.
- Extensions of thermometric scales.
- Methods of measuring absolute temperature.

Foundationalism:
"...[E]pistemic justification has a hierarchical structure. Some beliefs are self-justifying and as such constitute one's evidence base. Others are justified only if they are appropriately supported by these basic beliefs."

Coherentism:
No beliefs are self-justifying; and beliefs are justified in so far as they belong to a system of beliefs that are mutually supportive.

"[T]he real potential of coherentism can be seen only when we take it as a philosophy of *progress*, rather than *justification*." (Chang, pg. 224.)

"The initial affirmation of an existing system of knowledge may be made uncritically, but it can also be made while entertaining a reasonable suspicion that the affirmed system of knowledge is imperfect." (Chang, pg. 225.)

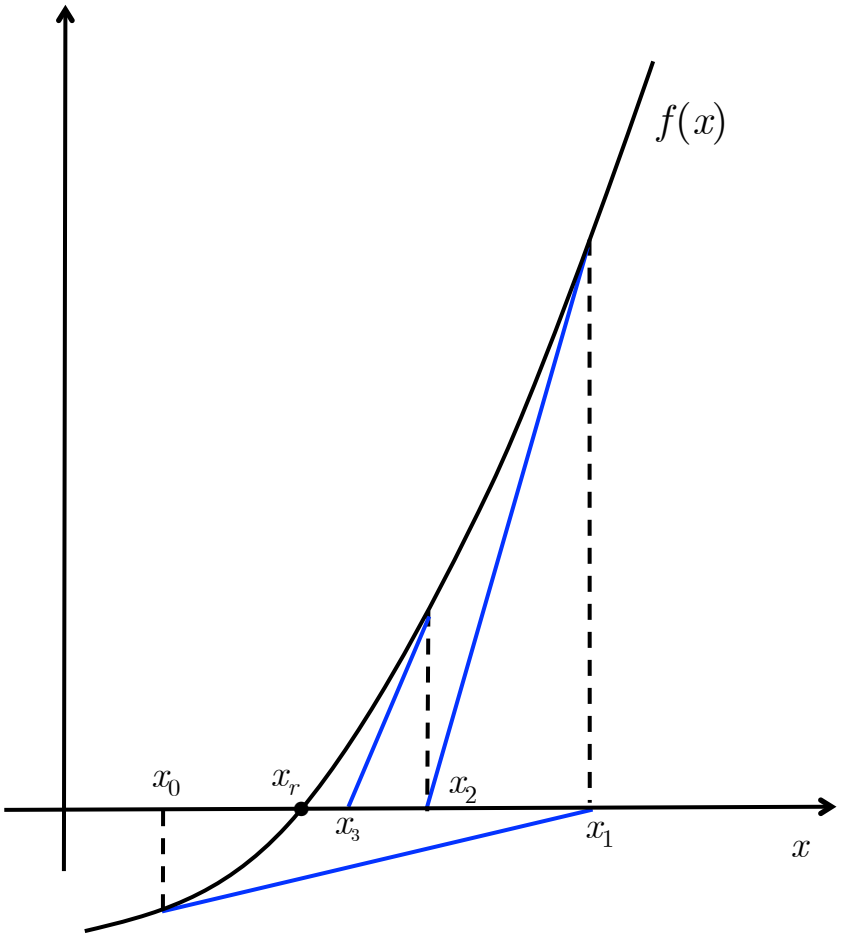
Ex. Newton's Method

Given a function $f : \mathbb{R} \to \mathbb{R}$ and its derivative f', find a root of f.

- *A value x_r such that $f(x_r) = 0$.*

Procedure:

1. Make an initial guess x_0.
2. Construct sequence $\{x_0, x_1, x_2, \ldots.\}$ where
$$x_{n+1} = x_n - f(x_n)/f'(x_n)$$
3. Truncate sequence when $|x_{n+1} - x_n|$ falls within a given tolerance.
4. *Claim*: For a given n, x_{n+1} sufficiently approximates the root x_r.



Potential problems:

i. Series doesn't converge.
ii. Initial guess is outside interval of convergence.
iii. Derivative issues.

- "Converge" means "there is an n afterwhich terms in the series are sufficiently close to x, but never reach it!
- When it works, the method doesn't produce exact value of x; just an approximation to it.

2. Epistemic Iteration.

"...process in which successive stages of knowledge, each building on the preceding one, are created in order to enhance the achievement of certain epistemic goals." (Chang, pg. 224.)

Fahrenheit's example: Attempted to measure temperature of mixture of fluids at different initial temperatures.

- *Source of error*: Initial temperature of mixing vessel affects outcome.
- *Solution*: Set initial temp of vessel to temp of mixture; but how to do this?
- *Chang's suggestion*:
  - Start with vessel at halfway temp between temps of fluids.
  - Measure temp of mixture
  - Set vessel temp to same temp as mixture and repeat experiment.
  - Repeat to reduce error as much as is required.

- When it is successful, how do we judge the degree of progress achieved by it?

Progress: "...the enhancement of any feature that is generally recognized as an epistemic virtue." (Chang, pg. 228.)

Examples of Epistemic Virtues:

- simplicity, support by more general theories, ability to predict previously unknown phenomena, credibility relative to background knowledge (Hempel 1966).
- accuracy, consistency, scope, simplicity, fruitfulness (Kuhn 1977).
- elegance, simplicity, completeness, unifying power, explanatory power (van Fraassen 1980).
- simplicity, testability, fertility, neatness, conservativeness, generality (Lycan 1988).

What about truth? "Even if truth is the ultimate aim of scientific activity, it cannot serve as a usable criterion of judgement. If scientific progress is something we actually want to be able to assess, it cannot mean closer approach to the truth." (Chang, pg. 228.)

Two types of progress produced by iteration

- *Enrichment*: "...the initially affirmed system is not negated but refined, resulting in the enhancement of some of its epistemic virtues."
- *Self-Correction*: "...the initially affirmed system is actually altered in its content as a result of inquiry based on itself."

Examples of Enrichment:

- "Bridge Street Bridge": nonsensical name of a bridge named after the street named after the bridge.
- *But*: "the apparent circular nonsense in the name is only a record of a very sensible history of iterative town development."
  - Initially, just one bridge in town and one street over it.
  - More streets are built, requiring names. Street over bridge gets christened "Bridge Street".
  - As more bridges are built, need arises to name them. Original bridge gets christened "Bridge Street Bridge".

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Examples of Enrichment:

- Process of quantifying operational temperature concept: from sensations to thermoscopes to thermometers.
  - Each stage built on previous stage by adding new dimension to it.
- Process of creating temperature standards for domains of extreme heat and cold.

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Examples of Self-Correction:

- Chang's scrathed-up glasses.
  - Glasses enable Chang to see their own defects.
- Thermoscopes based on sensations can correct sensations.
- Different thermometers enabled Regnault to see their own defects *via* comparability.
- Callendar-Le Chatelier operationalization of absolute temperature *via* iterative correction.

- Epistemic iteration in the context of coherentism = a particular type of scientific progress.

Characteristics:

1. *Conservative*: "it is based on the principle of respect, which demands the affirmation of an existing system of knowledge." (Chang, pg. 231.)
2. *Pluralistic*:
   (a) "Nothing ultimately forces us to stay entirely with the system in which we have been brought up."
   (b) "The affirmation of an existing system does not have to be wholesale..."
   (c) "It is also possible to choose the depth of affirmation."
   (d) "...the affirmation of an existing system does not fix the direction of its development completely."

Thus: "...the coherentist method of epistemic iteration points to a *pluralistic traditionalism*: each line of inquiry needs to take place within a tradition, but the researcher is ultimately not confined to the choice of one tradition, and each tradition can give rise to many competing lines of development." (Chang, pg. 232.)