

Epistemological bases

Popper, Gödel and the importance of
incompleteness in science

How much do we trust science(s)?

Philosophical bases of science: epistemology

Inductivism (Bacon, 1620)

Human mind is not a tabula rasa, it is a crooked mirror, on account of implicit distortions.

The scientific law as the result of a large number of observations.

Empiricism and Skepticism (Hume, 1740)

Experience cannot establish a necessary connection between cause and effect, because we can imagine without contradiction a case where the cause does not produce its usual effect...the reason why we mistakenly infer that there is something in the cause that necessarily produces its effect is because our past experiences have habituated us to think in this way.

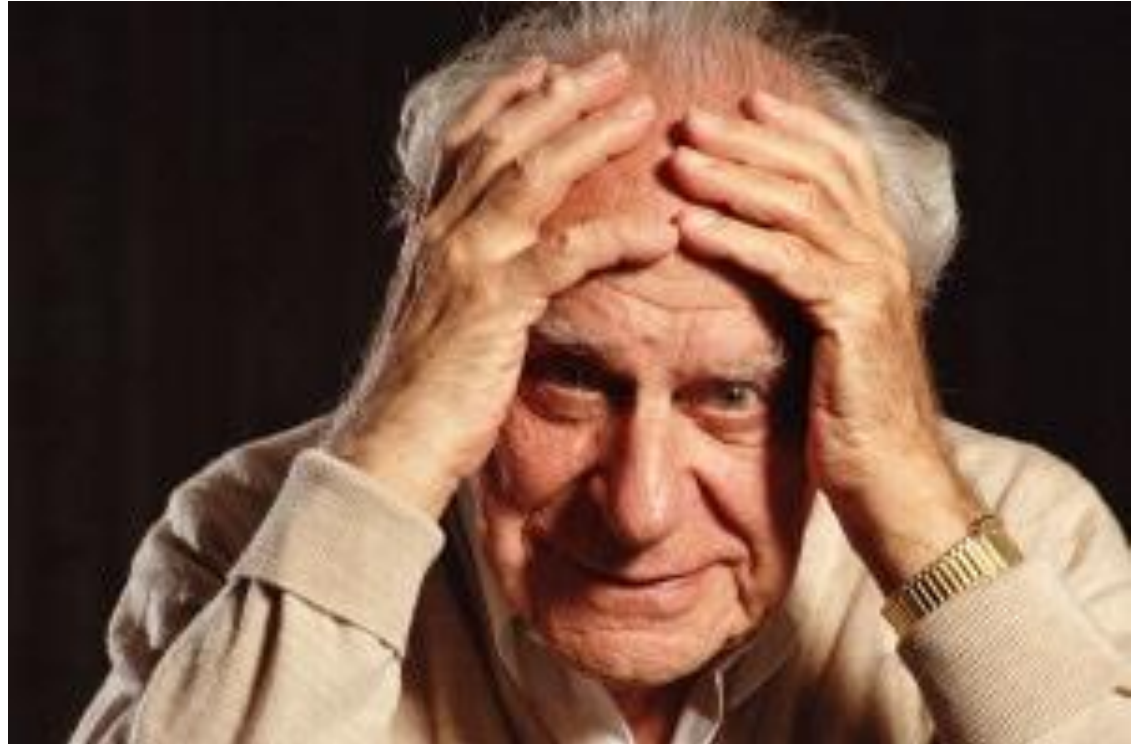
Verificationism (Comte and positivists, from 1820)

Attempts to find a method to definitively verify scientific laws (i.e., demonstrate that they are true). A statement is meaningful only if it is either empirically verifiable.

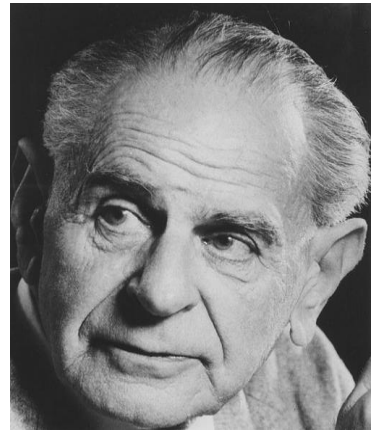
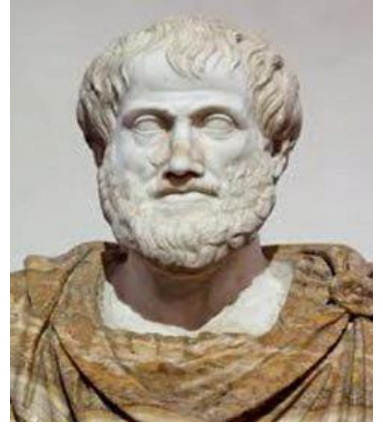
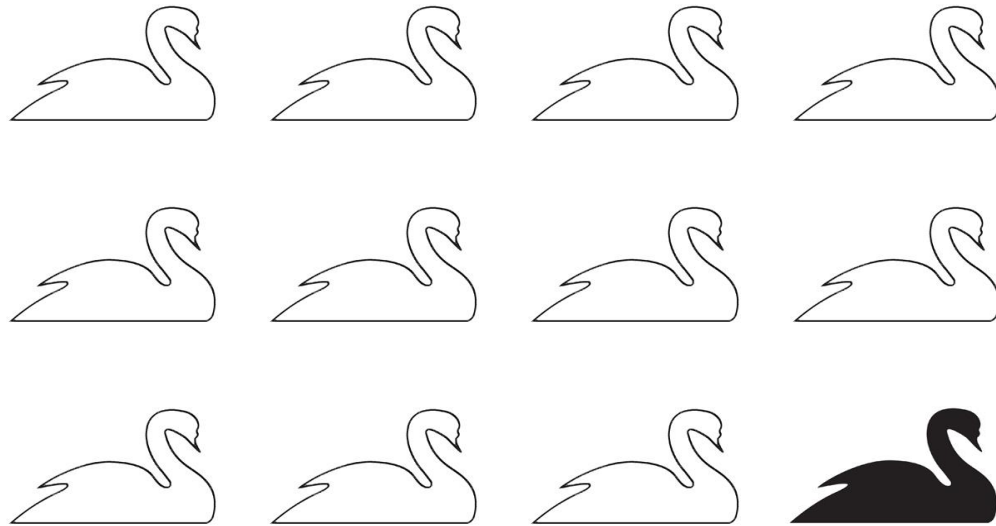
Karl Popper (1902 – 1994)

Falsificationism

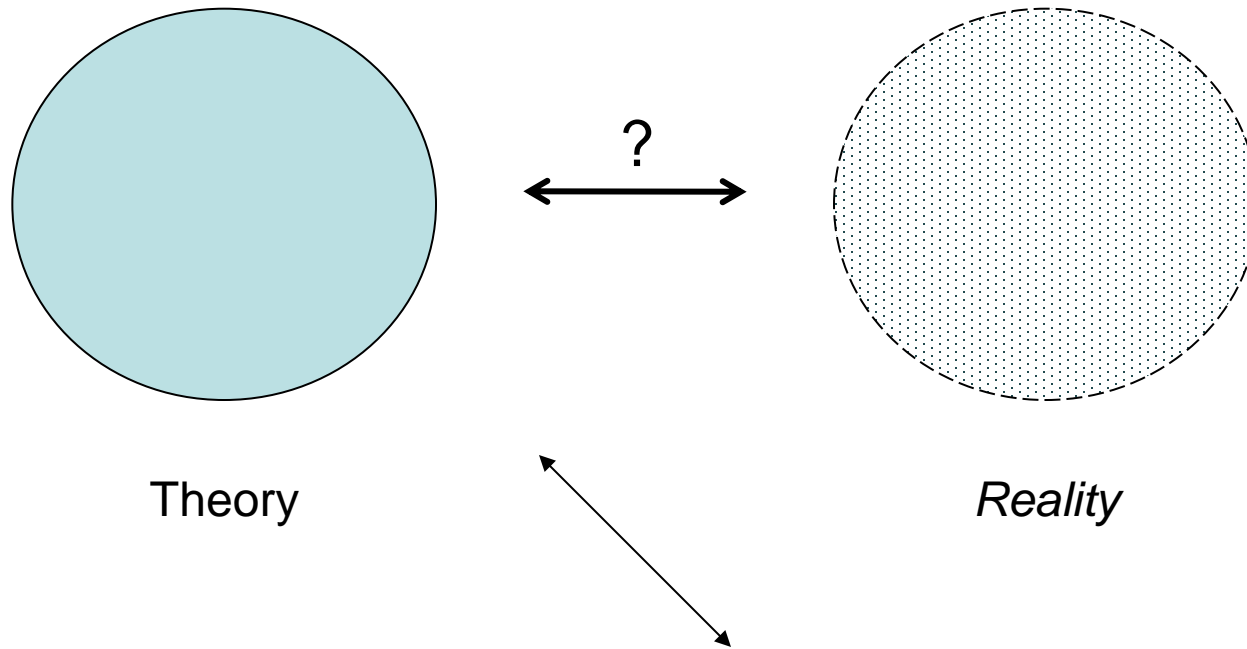
The logic of scientific discovery
(1934)



Refutation of inductivism





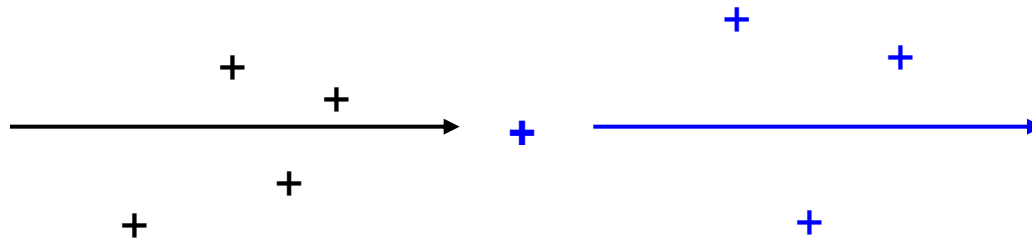


There is no way to prove a scientific theory (i.e., to demonstrate it is true in an absolute sense), because there are neither logical nor empirical criteria, or methods, to do so

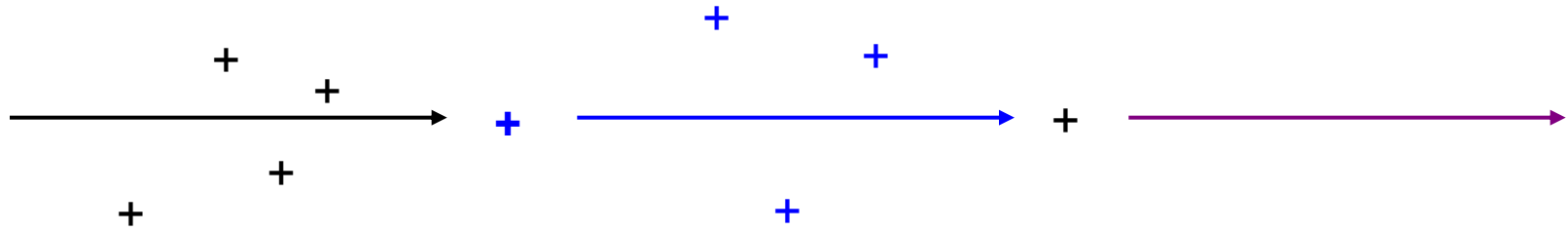
Scientific theories cannot be demonstrated

...but they can be **falsified** (i.e., **demonstrated** to be false)

Falsificationism



Falsificationism

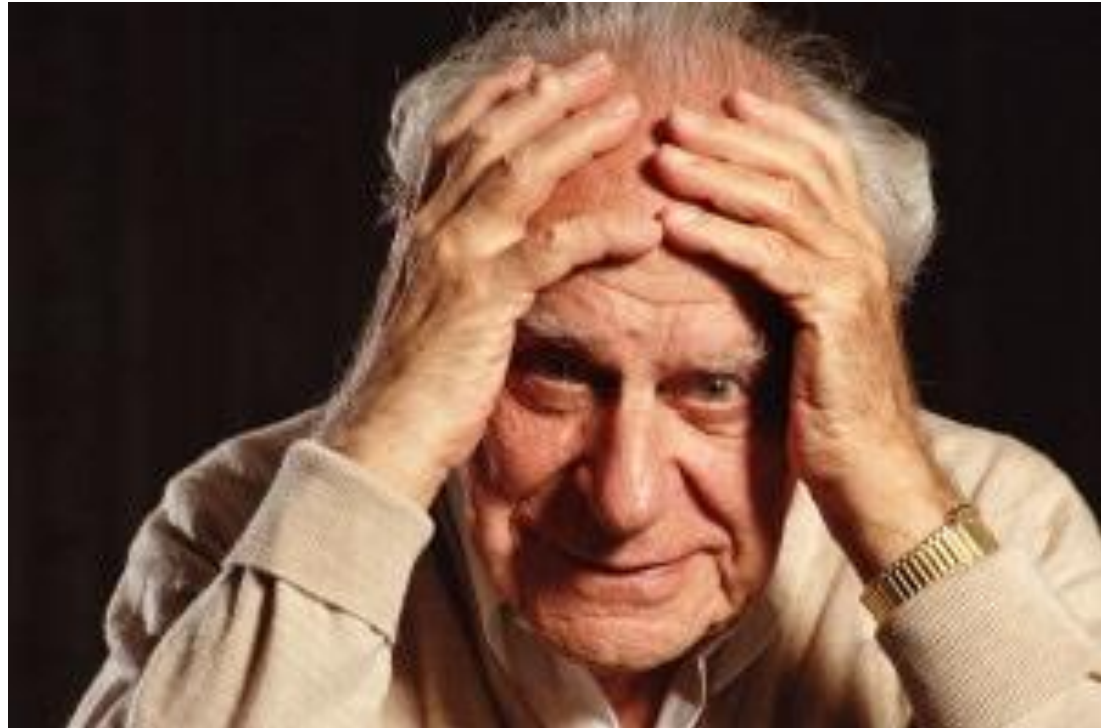


Karl Popper (1902 – 1994)

Falsificationism

Scientific theories **must** be falsifiable

To be falsifiable, they **must** make verifiable predictions



Inductive Reasoning

Observation



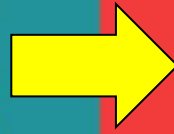
Pattern



Hypothesis



Theory



Deductive Reasoning

Theory



Hypothesis



Observation

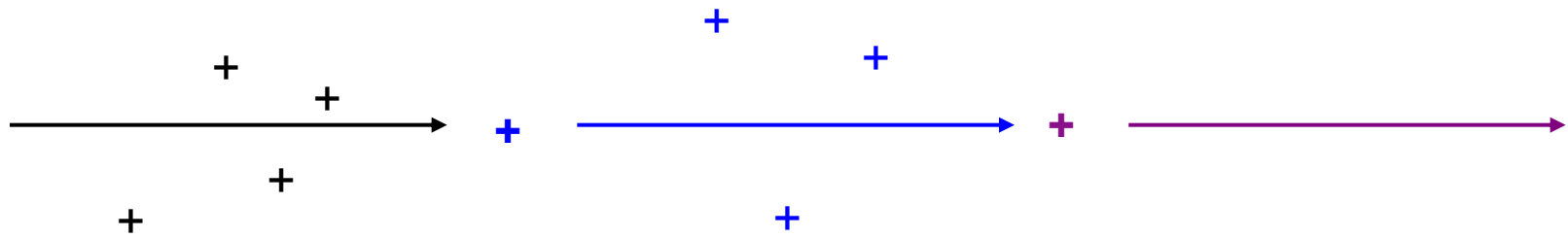


Confirmation

All human knowledge remains fallible, conjectural

Even if we devised a theory that adheres perfectly to reality, we will never be certain about that, because the only logically acceptable verification would be to perform all possible observations and conceivable experiments, which is clearly impossible.

Falsificationism



Adult cardiomyocytes are terminally differentiated (postmitotic)

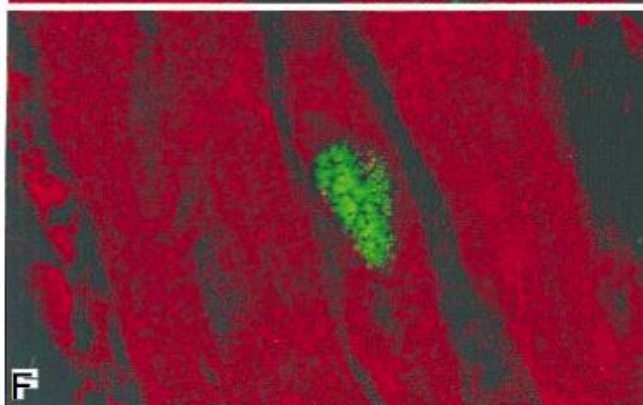
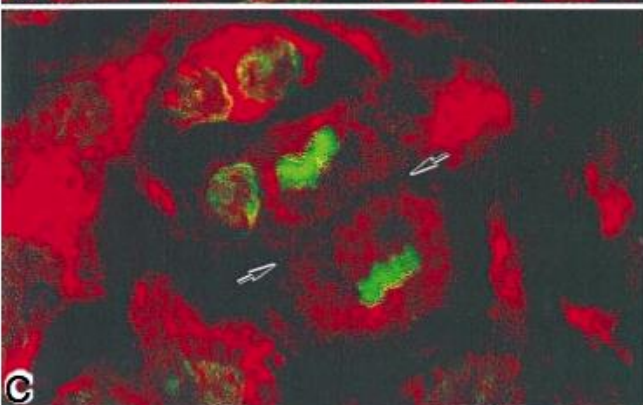
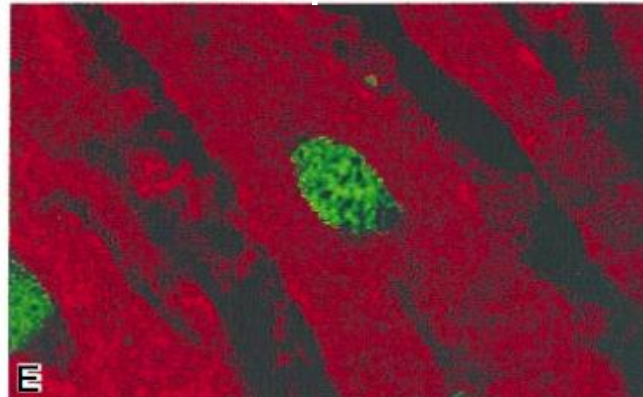
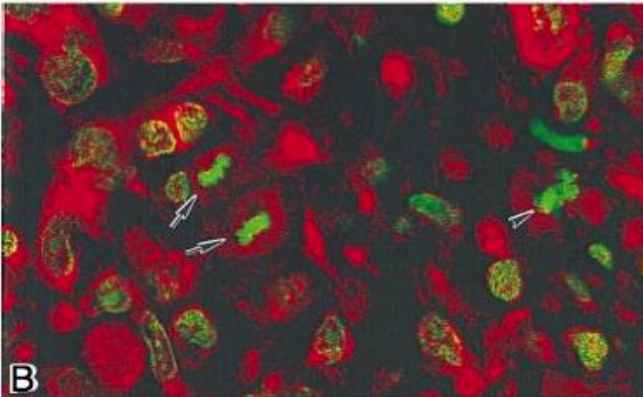
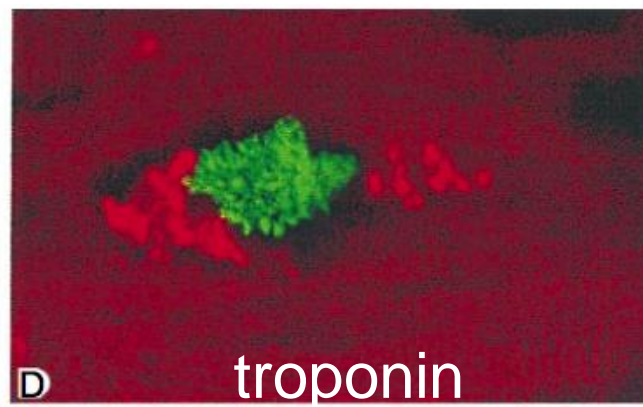
Proc. Natl. Acad. Sci. USA
Vol. 95, pp. 8801–8805, July 1998
Medical Sciences

Myocyte proliferation in end-stage cardiac failure in humans

(mitotic index/cytokinesis)

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**cardiomyocyte turnover=0.5–2%
per year**

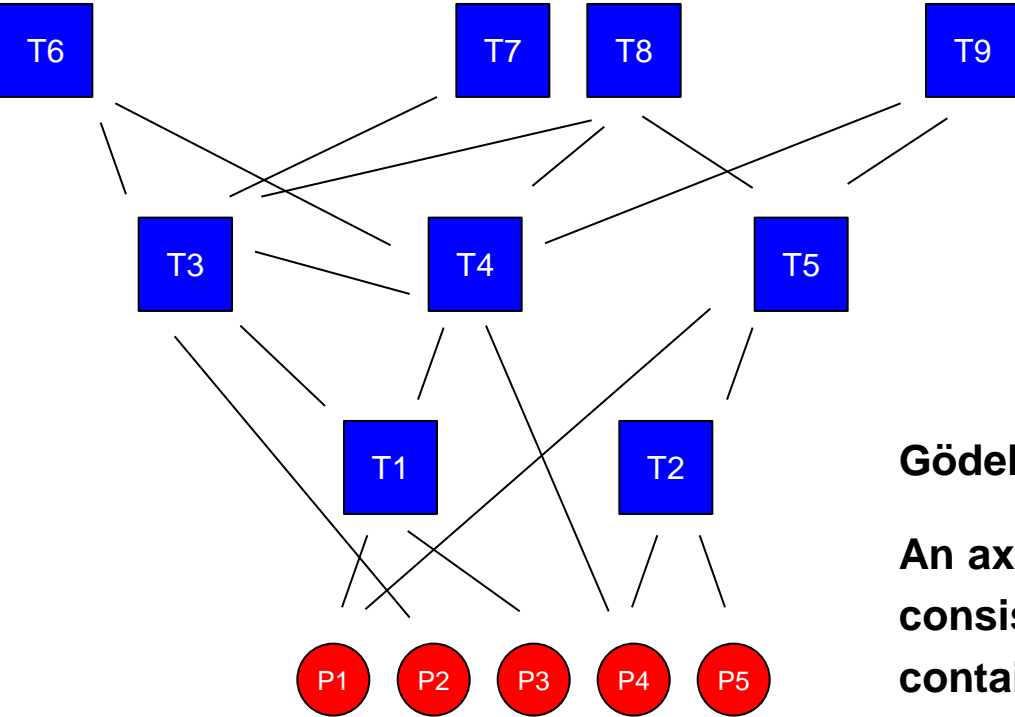
Circulation. 2017 August 15; 136(7): 680–686. doi:10.1161/CIRCULATIONAHA.117.029343.

Cardiomyocyte Regeneration: A Consensus Statement

All human knowledge remains fallible, conjectural

Even mathematics?

Kurt Gödel
1906 – 1978



Gödel's first theorem:

An axiomatic system that contains the arithmetics is consistent (coherent), but is also incomplete (i.e. contains at least one theorem which can neither be proved nor disproved. It can become a new axiom)

1931
Incompleteness
theorems

Gödel's second theorem:

The consistency of the axioms of an axiomatic system that contains the arithmetics cannot be proved within the system itself



La scienza cade in errore, per Popper, proprio nel momento in cui ambisce ad essere **quella giusta** o quella **definitiva** (Popper e "l'ortodossia quantistica degli anni '30).

- La caratterizzazione popperiana dell'uomo di scienza è, piuttosto, quella di colui che "non ambisce al possesso della conoscenza quanto piuttosto alla ricerca critica, persistente e inquieta della verità" (Popper, 1959, Logica della scoperta scientifica).
- La figura emblematica di Einstein, figura di sintesi della concezione popperiana di modestia intellettuale e pensiero critico e mosso da uno sforzo scientifico perpetuo.

Heisenberg rimprovererà ad Einstein la sua "incapacità di riconoscere alla meccanica quantistica il suo carattere di rappresentazione finale e completa dei fenomeni"

Ma Einstein, come Popper osserva nel suo poscritto ("La teoria dei quanti e lo scisma nella fisica"), non poteva accettare, neanche in ultima istanza, che la teoria dei quanti fosse eretta a base omogenea ed unica della fisica, poiché **intrinsecamente incompleta**

"Einstein affermò infatti: "Io credo che la rappresentazione quantistica non sia nient'altro che il prodotto di un'*interpretazione statistica della natura* e quindi un'*interpretazione incompleta delle sue stesse leggi*".

(Popper, 1956, *La teoria dei quanti e lo scisma nella fisica*)

“For now, what is important is not finding
the answer, but looking for it.”

- Douglas R. Hofstadter, *Gödel, Escher, Bach: An Eternal Golden Braid*

