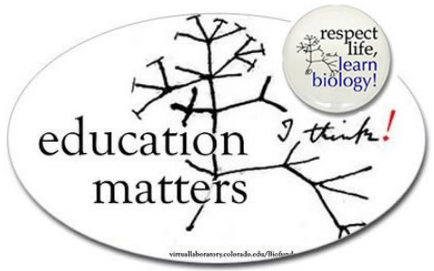
# TaLB - Next Section (tonight) - Klymkowsky

- **Today**: How do we make sense of the world?
  - Magic, religion & science
  - What makes teaching, understanding, and accurately applying scientific explanations problematic?
  - What does it take to understand something scientifically?
  - What are core concepts (ideas) in biology?
- **14 September:** How do we assess scientific understanding
- **21 September:** Challenges of evolutionary thinking
- **28 September:** Thinking about systems (mainly molecular)
- **5 October:** Paul Strode takes command

Remember what Snoop Dogg sez website



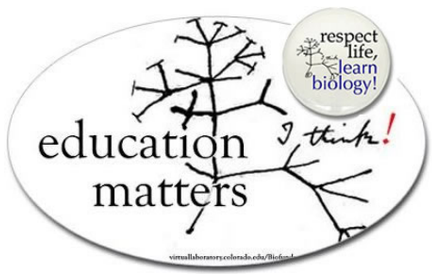
## Consider the differences between the sciences

Physics as the "ideal"

- Relatively simple system composed of theoretically identical components
- General rule - variation is noise

Biology in practice

- Remarkably complex systems (organisms+)
- Products of historical and stochastic processes
- Variation is the raw material for evolution (each individual is unique)




*"Few physical scientists understand the uniqueness of individuals," - E. Mayr*

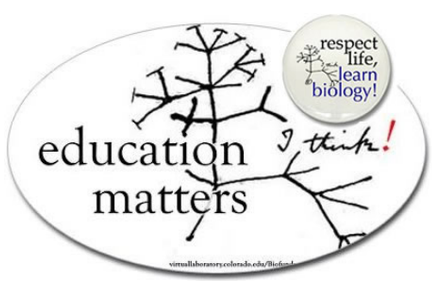
# Biology Is Not Postage Stamp Collecting

***Ernst Mayr, the eminent Harvard evolutionist, explains why he thinks some physical scientists have a problem with evolution***

SCIENCE,VOL.216,14MAY 1982

*"The people who come from the physical sciences have an enormous amount of difficulty with evolutionary biology ...*
*This was **Karl Popper**'s problem.*
*At first he said the 'just so' stories of natural selection cannot be proven, and evolutionary biology is not really scientific.*

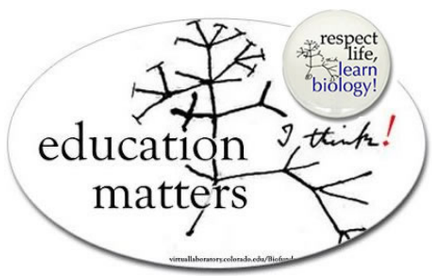
*It is not, as the British physicist **Lord Rutherford** contended, just postage stamp collecting." Ernst Mayr*



*"Many geneticists still define evolution in terms of changes in gene frequencies, thus demonstrating that they do not understand that* ***the individual as a whole is the target of selection****, not individual genes." - E. Mayr*

*"When you bring this to the attention of geneticists they will say, I agree with you, and then when they write their papers they will just ignore it again." - E. Mayr*

*"Two years ago I saw a paper … and the author wrote,'Let's assume the gene has a constant selective value; let's assume there is no gene flow from any other population.'He made about five such assumptions, each of which was equally unrealistic, and then he went on to prove something very beautiful mathematically, but it was meaningless." - E. Mayr*

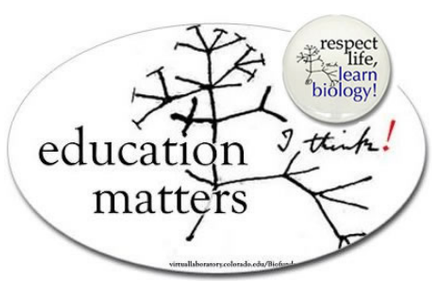


*"If you had stood on the earth at the beginning of the Cretaceous [135 million years ago] and seen dinosaurs all over the place, you could not have predicted that the miserable little things that came out only at night would eventually take over when the Cretaceous came to an end.*

*You can predict the next appearance of Halley's comet, but you can't predict changes in biological diversity. Such uncertainty is typical of evolution." - E. Mayr*

*"New properties (emergent behaviors) turn up in systems that could not have been predicted from the components, which means you have to study things hierarchically.*

*Reductionism can be vacuous at best, and, in the face of emergence, misleading and futile." - E. Mayr*



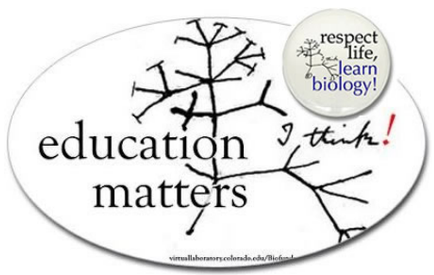
# Cause and Effect in Biology

**Kinds of causes, predictability, and teleology are viewed by a practicing biologist.**

Ernst Mayr

**Proximal cause (how)**: How something occurs at the molecular, cellular, organismic, ecological level

**Ultimate cause (why)**: How something occurs at the molecular, cellular, organismic, ecological level



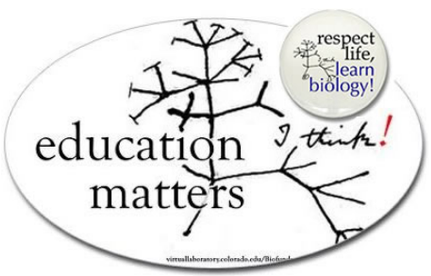
**Just a work on (my) background:** experimental molecular/biologist - trying to understand how molecular machines and system “work”.

# Week 2.1: Sabine Hossenfelder -
# How to tell science from pseudoscience (and magical thinking).

You have already watched **Sabine Hossenfelder:**

- How to tell science from pseudoscience & Flat Earth "Science": Wrong, but not Stupid.
  - COMMENTS before we break into groups?
  - First group (20 minutes) includes
    - ~5-10 minutes getting to know one another
    - 10 minutes coming to a group response to assignment

- Give two or three examples of common pseudoscientific beliefs and magical thinking in the world and science.
- How would you address (in your teaching) the personal empiricism described in the flat earth video? or religious objections to scientific theories?
- Consider how you, yourself, evaluate evidence and explanations in biology
- Describe how you might you assess the effectiveness of your teaching regarding topics associated with pseudoscientific and magical thinking?

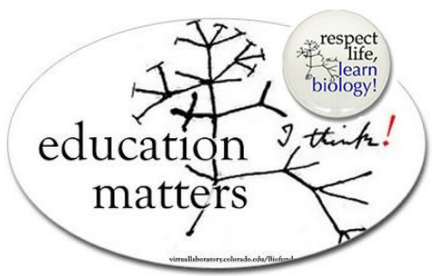


# Report back- Hossenfelder

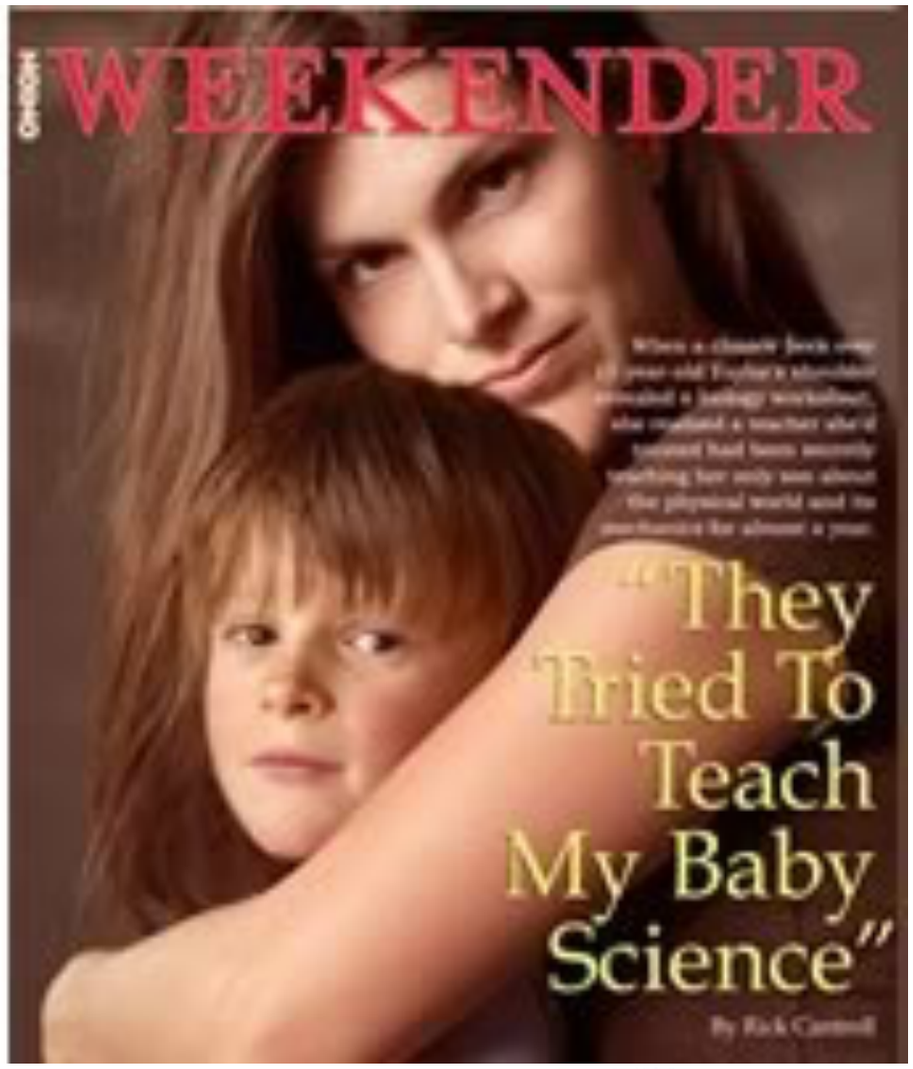
- Give two or three examples of common pseudoscientific beliefs and magical thinking in the world and science.
- How would you address (in your teaching) the personal empiricism described in the flat earth video? or religious objections to scientific theories?
- Consider how you, yourself, evaluate evidence and explanations in biology
- Describe how you might you assess the effectiveness of your teaching regarding topics associated with pseudoscientific and magical thinking?

**Week 2.2**: after reading John Gray Science, Religion & Magic

- Summarize briefly the difference (in your words) the differences between the three (science, religion, magic)
- How might you tell when scientists are displaying magic thinking?

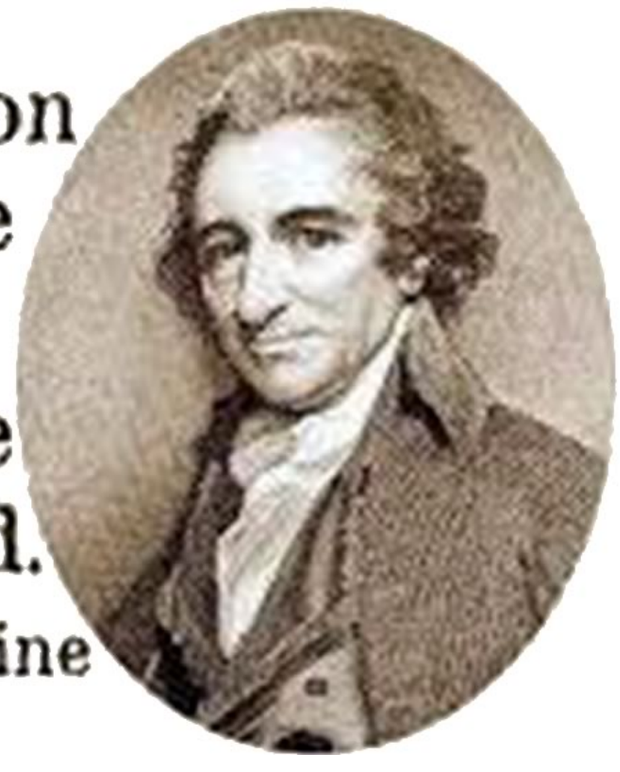


- **Paul and Andy?** Best approaches to teaching (communicating) disconcertaing ideas.




To argue with a person who has renounced the use of reason is like administering medicine to the dead.

• Thomas Paine

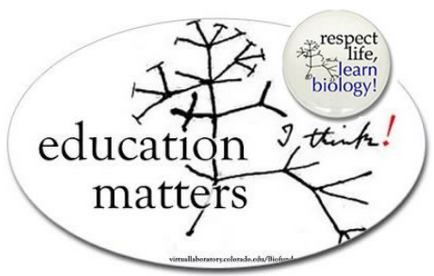


# Report back - Gray

- Summarize briefly the difference (in your words) the differences between the three (science, religion, magic)
- How might you tell when scientists are displaying magic thinking?

**Week 2.3**: After watching Feynman on Magnets

- How you decide on the level of detail you will present to students?
- What do you expect students to due with what you tell them?
- How will you assessment student learning on the subject presented.

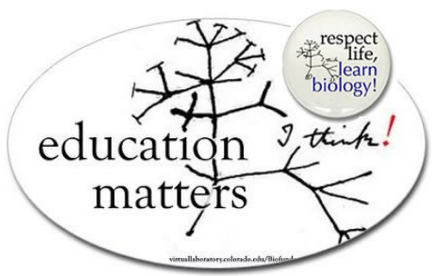


## Report back - Feynman

- How you decide on the level of detail you will present to students?
- What do you expect students to due with what you tell them?
- How will you assessment student learning on the subject presented.

**Week 2.3**: After reading Foundational Concepts in Biology

**Write out your thoughts** on
1) What you would add or removing from the list of core concepts necessary for understanding biological systems.
and
2) what core concepts from "outside of biology" are essential for understanding biological systems?



Evolutionary thinking & mechanisms

modified from Klymkowsky 2010.

- continuity of life (cell theory)
- stochasticity (noise, mutation, drift)
- selection → information generation

} physics & chemistry

Molecular foundations

- thermodynamics: enthalpic & entropic factors
  - membrane assembly / protein folding
  - bond formation and catalysis
- molecular interactions (affinty, specificity & regulatory (allostery)
- molecular level effects of mutations

Network behaviors

- non-equilibrium networks
- systems behaviors (feedback/feedforward interactions)
  - homeostatic, adaptive & evolving (development) processes
  - check / decision points
  - processes: i.e. developmental, neural, immunological, ecological (pathogen/prey)

# Report back - Concepts

1) What you would add or removing from the list of core concepts necessary for understanding biological systems.
and
2) what core concepts from "outside of biology" are essential for understanding biological systems?

**Update your dossiers**

How has your thinking changed (or has it).

What insights (if any) have you had that are relevant to teaching a particular topic in biology?