Strategies for Teaching Evolution in High School Biology



Humans did not evolve

from monkeys or apes.

Rather, humans, monkeys and apes all have evolved from an earlier form of life that we all share ~7+ mya

The March of Progress Image

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Why Can Evolution be Challenging for Teachers?

- Less than 50% of American adults know that humans developed from earlier species
- Lack of preparation to deal with such conflicts for pre-service (and other) teachers
- Evolution is seen by some as a threat to personal worldviews
- Lack of understanding about evolution and how it works
- Ignorance on the part of the educator
- Little to no administrative support
- Students have prior conceptions
- Pressure from the community
- Pupil and/or parent reactions
- Absence of quality resources
- Personal conflictions
- Complexity of topic

What Other(s)?



Evolution | National Center for Science Education. (2024). https://ncse.ngo/evolution

Tolman, E. R., et. al. (2021). Barriers to teaching evolution in higher education. Evolution Education and Outreach, 14(1). https://doi.org/10.1186/s12052-021-00151-1

What Strategies Can be Employed to Minimize Conflict when Teaching Evolution?

- Indiana Standards: HS-LS4: 1-6 Biological Evolution: Unity and Diversity
- Avoid Religious/Supernatural Explanations in Class (creation science / intelligent design)
- Stress that Science Develops Explanations of the Natural World by Gathering Evidence
 - Scientific information based on best current evidence / creditable resources / reviewed
- Begin at Beginning of the Year / Integrate Throughout the Year
- **Provide Real-World Examples** (i.e. antibiotic resistances)
- Focus on Science and Scientific Literacy
 - Evolution not a "believe"; Theories explain "how"
- Have Students Read / Hear Topic from Someone Else (text, videos, guest speaker)
- Diversify by discussing all/most Kingdoms of organisms
- Affiliate with a State and/or National Organization: IABT, HASTI, NSTA, and/or, NABT



Doe. (2024, September, 4). Science & Computer Science. DOE. https://www.in.gov/doe/students/indiana-academic-standards/science-and-computer-science/

Evolution: Strategies for Minimizing Conflict about Teaching Evolution. (2024). https://www.pbs.org/wgbh/evolution/educators/course/session8/elaborate_c_pop1.html

What Strategies Can be Employed to Minimize Conflict when Teaching Evolution..cont.?

- Be Knowledgeable/Excited about Evolution
 - Dispel misinformation
 - Research questions prior to class
- Create a Respectful Learning Environment



- If asked to teach an alternative, you legally are not allowed (Senate Bill 373, 2019)
- Redirect religious questions back to science or outside class time; don't argue in class
- Students are expected to know about evolution; but how they integrate it is up to them
- Beliefs do not have to be in conflict; but, this is a science class treat it as so
- Best not to express your own personal options
- Use Sound Pedagogy
 - Engage students with active learning experiences (via lectures/labs/activities/etc)
 - Present science as an ongoing process; not a final conclusion
 - Change is expected (and accepted) in science and must be testable

What Other (s)?

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How Do I Prepare Students for Evolution?

- Hierarchy of Life: identifying macromolecules lab / cereal enzyme
 - atoms \rightarrow biosphere
- Basic Taxonomy (ie. humans)
- Biological Tools:
 - microscopes, probeware, glassware/hardware, etc...





- Scientific Method: sewer lice, prisoner escape trick, that's how the cookie crumbles
 - stressing proper observations / reliable research / open minded
 - defining hypothesis
 - control, IV, DV
 - creating suitable procedures/results/conclusions





How Do I Prepare Students for Evolution...cont?

- **Spontaneous Generation**
 - history (ie. Redi / Pasteur: swan-neck flask)
- **Define Theory Explains "How" Something Happens**

- allows for peer review

- prevents social ignorance

avoids stagnation of knowledge

- established facts
- testable hypothesis
- confirmed results
- based on SM
- can be modified / replaced
- **Conceptualizing Time**
 - football field = 94,000 yrs
 - 1000 sheet (ea 4.5 m.y.) of T-paper = 4.5 by ; leaf blower



How Do I Prepare Students for Evolution..cont?

- History of Life
 - Earth Hominids (lesser and greater modern/extinct apes / humans)
 - Hominins: *Sahelanthropus* ~7-6 mya → *Homo sapiens* ~315 mya present
 - grand canyon, Pangea, asteroid, ice ages, etc...
- Defining Descendent vs Related
- Examples of Non-Living that Have Evolved















How Do I Discuss Evolution with Students?

- Defining Evolution
 - descent with modification; "change"
 - beneficial mutations, natural selection, and heredity
- Phylogenetic Cladograms / Trees
 common ancestry / common traits
- History (ie Wallace ; Darwin: Galapagos / Origin of species)
- Evidence for Evolution: "Stressing Common Ancestry"
 - Convergences (ie. dolphin vs shark (body)
 - Fossils (ie. whales / horses)
 - Anatomy (ie. bones)
 - **Embryology** (ie gill slits / tail)
 - Genetics (ie DNA (human vs chimp ~ 1.2% diff.))
 - Transitional Life Forms (ie Tiktaalik)







Frayfinned @ 🕼 🥙 📣

What Else Do I Discuss with Students?

0.00

S.,

0.15

Bacterial growth at 15-minute intervals Non-red bacteria indicate mutated forms

0.30

0.45

1.00

Others:

- Macro vs Microevolution
- Coevolution
- Artificial Selection
- Genetic Drift
- Speciation
- Subpopulation Isolation
- Genetic Equilibrium
- Summarize the Lesson
 - Common Misconceptions
 - Evolution is Like a "Puzzle"
 - Time
 - Data
 - Tools
 - Knowledge
 - Questioning

- Evidence
 - Investigating
 - Experimenting
 - Open Mindedness









What Do I Do to Supplement Evolution?

- LbL "Learning Before Lecture"
- Color Assignments "Reinforcement/Pictorial"
- Simulations
 - Modified Telephone Game
 - Peppered Moth Game Online
 - PhET Natural Selection Online
- Labs / Activities
 - Phylogenetic Activity: Cladogram / Tree
 - Right Beak for Evolution
- Dress the Part
 - Charles Darwin ; Celebrate Darwin Day: Feb 12th, 2025









How Do I Discuss Evolution with my "Advanced Biology" Students?

- Review Evolution
 - Discussion / Provide PPt Lecture Notes
 - Utilize the Evolution & Genetics Resources on HHMI Bio-Interactive
 - Explore and Reflect on Topics from the PBS Evolution Website
- APA Research Paper
 - Ball State Library Created a Webpage for the Assignment
- EVO: 10 Questions Everyone Should Ask
 About Evolution; J. Feldman Discussion
- Amazing "Human" Race Activity Game
 see Sample Grant for Skulls







EVOLUTION OF THE SKULL





Favorite Resources

Literature:

Your Classroom Text "The Blind Watch Maker", Richard Dawkins **"The Readable Darwin", The Origin of Species, Jan Pechenik** "The Greatest Show on Earth", Richard Dawkins "Charles Darwin and His Revolutionary Ideas", Brain Ellis "Evolution: The Story of Life On Earth", Jay Hosler "Why Evolution is True", Jerry Coyne **"The Universe Within"**, Neil Shubin "Your Inner Fish", Neil Shubin **"Domesticated"**, Richard Francis "Undeniable", Bill Nye "Dawin's Ghosts", Rebecca Stott **"Endless Forms Most Beautiful", Sean Carroll** "Darwin's Backyard", James Costa **"30-Second Evolution"**, M. Fellowes and N. Battey "Answers Book 1 and 2", Ken Ham – not on evolution



HE NEW SCIENCE OF EVO DEVO

SEAN B. CARROL

YOUR INNER FISH

A JOURNEY INTO THE 3.5-BILLION-YEAR HISTORY OF THE HUMAN BODY



NEIL SHUBIN

Favorite Resources

Media:

Evolution: Darwin's Dangerous IdeaNOVA: Becoming Human Unearthing Our Earliest AncestorsDarwin's Brave New WorldInherit the WindWelcome to Mr. Butler'sCreation (P. Bettany and J Connelly)ClassroomOnline:Image: Image: Im

https://humanorigins.si.edu/ https://darwinday.org/ https://evolution.berkeley.edu/ https://www.pbs.org/wgbh/evolution/

https://naturalhistory.si.edu/

Best Part of the Webpage Student Work and Selected Class Links

<u>https://www.biointeractive.org/</u> (ie Making of a Theory, Your Inner Monkey, and Great Transitions, etc...) <u>https://www.sciencefriday.com/educational-resources/science-friday-discussion-negotiating-the-challenges-of-</u> <u>teaching-evolution/</u> (Science Friday "Negotiating the Challenges of Teaching Evolution")

> www.rm118.com (see Menu: Trips, Resources, Links) Selected Professional Presentations





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Thank You

The famous 'I think' sketch from Charles Darwin's famous red notebook 'B' (mid 1837, p. 36).