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There’s a Dragon in my classroom

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There’s a Dragon in my classroom

(presentation formerly known Science & Spaghetti Monsters… same essential content, new flashy title)

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Why is this 'my thing'?

Where is my freshman college roomate?

- In love with biology for years, advanced classes in high school , and complete buy in for all things science
- New (very religious) roomate seeing my biology books asks *"You don't believe in that Evolution stuff do you?"*
- Me: *"Ummmmm. Yeah, sort of…"*
  - I had no idea how to address this with a new person who I was going to have to live with for a very long time: **Avoidance!**

6+ years later…

- Extensive coursework in evolution, statistics, animal behavior, etc to go with molecular biology research
- At my Master's defense, a professor asks (in the middle of discussion related to molecular genetics), *"Do you believe in Evolution?"*
- Did I have a better answer? Nope, just more **enthusiasm**!

- *"OF COURSE I DO!"*

What's wrong with this picture?

- When caught off guard, I felt defensive or unsure of how to respond (so I blurted).

- I did not have a clear response pattern to draw from and couldn't clearly (and concisely, under pressure) explain the differences between common understanding of 'belief' and scientific reasoning.

- My professor did that to demonstrate a point (albeit somewhat embarrassingly) that knowing the science isn't enough when these questions come up, and <u>our ability to communicate about them effectively is key</u>.

Semantics and Specifics

Presentation will be broken into:

- How do we talk about science in a broader context in our classrooms? (and how does this relate to approaching controversial topics)
  - Is much of this common sense for experienced teachers ? Maybe! But classrooms are crazy, and unexpected can throw us off our games. Let's be ready…
- What are some focal points for specific examples of these sorts of topics in biology?
  - Focusing on evolution, genetic information, and genetic modifications
  - Ideas for other topics

What makes science, science?

How do we help students make sense of the science they are learning and how it fits in with preconceived notions and misconceptions, social perspectives, and potential controversy?

“There’s a Dragon in My Garage”

-from Carl Sagan’s <u>Demon Haunted World 1</u>

Show me," you say.

I lead you to my garage. You look inside and see a ladder, empty paint cans, an old tricycle -- but no dragon.

"Where's the dragon?" you ask.

"Oh, she's right here," I reply, waving vaguely. "I neglected to mention that she's an invisible dragon.“

You propose spreading flour on the floor of the garage to capture the dragon's footprints.

"Good idea," I say, "but this dragon floats in the air.“

Then you'll use an infrared sensor to detect the invisible fire.

"Good idea, but the invisible fire is also heatless.“

You'll spray-paint the dragon and make her visible.

"Good idea, but she's an incorporeal dragon and the paint won't stick." And so on. I counter every physical test you propose with a special explanation of why it won't work.

- Ok, scientists… now what?

“There’s a Dragon in My Garage”

- What conclusions can you draw?
  - Testing and observation show that there is no dragon
  - There could be a dragon, but it is not currently observable or testable with the scientific means that we have available
  - The existence of the dragon is outside the realm of what is testable or supported through scientific means

Any of these conclusions are valid, but all point to acceptance of a dragon in the garage being outside of what we can validate through scientific method.

Why do we care about dragons?

(or spaghetti monsters)

- One of the most important things you can teach your students is how to differentiate science from other non-scientific ways of viewing the world, and to identify pseudoscience or poor scientific reasoning.
  - This includes differentiating scientific debate (hypotheses still being tested, conflicting results, etc) from non-scientific controversy

- Science, by definition, is testable and falsifiable. If you cannot test something to see if it can be rejected, we do not consider it science.

Can you believe in dragons? Is it exciting to consider how a resident dragon might improve the well being of your home? Could you decide to park your car on the street so you don't bother your new pet?

You could potentially do any of those things, but you must appreciate that the decisions you are making are not based in a scientific perspective.

Draw the Line

- Some of the supposedly controversial topics that come up in science classrooms can be handled simply by defining what is science and what is not.
  - Make it clear that there are many ways that people make sense of the world and their place in it, but in a SCIENCE classroom, you will only examine those the scientific perspective
    - Shows respect for other 'ways of knowing' (religion, philosophy, etc.) but clearly draws the line

Draw the Line

- Suggest that even scientists often have multiple ways in which they view the world (there are many very religious scientists for example) but they know how to differentiate which ways are scientific and which are not
  - This helps students realize that understanding science is not mutually exclusive of other perspectives that may be important to them.

It’s not about the science

Handling controversial topics, or topics which students may have many misconceptions about, successfully in the classroom is not just about the science .

Most teachers who shy away from addressing controversial topics do so because they are uncomfortable handling the potential conflict, rather than a discomfort with the scientific content itself.

Why? Often lack of training, mentors, and experience. If our own teachers avoided it, too, we have no real examples to follow. This perpetuates some of the problems.

Harmful Dragons

- The hardest problems or conflicts to deal with are not necessarily related to non-scientific perspectives, but when non-scientific perspectives are used as if they are scientifically valid. For example:
  - Opposition to widely scientifically supported conclusions (when criticisms not supported by scientific evidence)
  - Attempted inclusion of non-scientific perspectives in science classrooms

Identify your own Dragons (and keep them in the garage)

- Scientists (and teachers) are not un-biased.
  - We all carry our own beliefs about the world, many of which may fall outside our knowledge of science.
  - We may unintentionally harbor 'harmful dragons' because we don't have enough information to formulate a supportable scientific perspective

- Our job is to teach students how to make sense of the world from a scientific perspective ONLY.

- We must reflect on our own perspectives, and be cognizant of how they impact our responses and interactions.

Be the guide, not the guru

- Rather than giving your own opinion, focus on asking questions or providing evidence
- Why is this hard?
  - We have enough expertise to have a valid opinion on certain subjects
  - We may feel passionately about a subject
  - We have a habit of being the authority, and it's easier to just give an answer, rather than guide to one

Be the guide, not the guru

- Why is this important? (and it's so, so important)
  - Students look to you as an authority on which to base their decisions. This can be good. But what happens when you are not there, and a new question arises?
    - They need the skills to do this on their own
    - They do not have the same context that you do, and building that context is important
    - If you provide answers, instead of tools, you risk sharing an opinion that you may end up changing down the road (i.e. if new evidence comes to light). You can reevaluate your own decisions, but your students only walk away with what you have given them

What NOT to do…

- Teach the science, but then offer your own non-scientific perspectives

For example: Teachers bringing up in discussions how they had problems getting in arguments with students about how their personal religious viewpoints and Evolution fit together

  - Not your place to share religion/personal philosophy/etc in a science classroom
  - You are losing objectivity and potentially ostracizing students who have different perspectives and backgrounds
  - Don’t fall back on “if you talk to me outside of class, I’ll share my opinion”. You are an authority to the students, regardless of the room, and the same risks are present.

You owe it to your students to be able to do what you expect of them…. Be an example in your ability to separate science from that which is not scientific.

What NOT to do…

- Give opinions you don't feel qualified for (or on things that should not be opinion based)
  - Visitors to IMSA from China: "We know this is a big debate in your country. Do you believe GMO's are safe"
  - Me: "Well, I know that there's a lot of data that suggests that many modified crops are just as safe as others, but I'd like to see long term data on modifications and how they might impact humans, and our ecosystems…etc, etc, etc"
  - Them: "But do you believe they're safe?"
  - Me: ::similar commentary as before::
  - Them: "But what we want to know, is would you buy them at the grocery store?"
  - Me: "Well, that's something personal, not something I'd share with my students, and would not change how I teach about this topic."

What NOT to do…

- Why was I so insistent about not answering?
  - I don’t believe it’s a clear cut yes or no question, as they were asking.
  - I didn’t have enough concrete (scientific) evidence in my head or easily accessible to give an opinion I’d be comfortable defending
  - I think continued questioning is more important than having a single answer to stick by
  - Back to the issue of guide vs guru… I don’t want others basing their decisions off of my answers, I want them to make their own informed choices

What NOT to do…

- Let your personal bias impact your objectivity and fair treatment of students
  - For example: I think the "Food Babe" is completely ridiculous for her war on big chemistry words she cannot pronounce. She fills me with rage and promotes my desire to drink more Starbucks pumpkin spice lattes, just on principal.

What NOT to do…

BUT… If I openly mock her and the stupidity of what she promotes to my students, and one of them has a parent that is a huge fan and follower, what have I accomplished?

- Ostracized the student and likely made them uncomfortable
- Possibly made them less receptive because I've challenged someone who is their default authority figure
- Lost my reputation for objectivity (it's become a personal attack)
- Made my students feel like if they might have a misconception or have believed something that I think is incorrect, I'm going to think they're an idiot.
- <u>No positive outcome!</u>

What NOT to do…

- Promote debate (in a science specific classroom) about non-scientific ideas. Have a plan for if they arise on their own.

  - For example:
    - Creationism or Other Religions view vs Evolution: religions are, by their own definitions, not scientific, so this is not a scientific debate, and does not have a place in your science classroom.
      - If it comes up, reiterate definitions of science and non-science.
    - Whether there's a secret conspiracy of pharmaceutical companies trying to prevent scientists from finding cures for diseases like cancer.
      - If it comes up, ask students to think about why cures might be challenging or even impossible for some diseases, and how misunderstandings about them might influence perspectives of those outside science in their opinions.

What NOT to do…

- Whether it’s right for parents to be able to choose to ‘opt out’ of vaccinations.
  - If it comes up, ask questions about what evidence would be needed to make a decision about proper vaccination schedules and the risks of non-vaccinated individuals to others.

    - ***Note: Asking for what kind of evidence students would want to see in order to make their decisions is a good segue into actually showing evidence or at least re-focusing on the scientific perspective (what is known)***

So, what can you actually do?

Be consistent & Be prepared

- Have ‘canned’ responses
  - “I thought science and religion were opposed on the issues of X”
  - “Remember that science refers to things that are falsifiable, so from the scientific perspective, it’s not really a conflict, we can just only work with evidence and data that are scientific. Other perspectives just fall outside that umbrella”

Be consistent & Be prepared

- Predict what might come up
  - What's in the news?
  - What backgrounds do your students have and how might that influence preconceived notions?
  - What are common misconceptions/perspectives among the public?

Focus on Evidence, Not Opinion

Typical Questions	Better Questions
What's your opinion on X?	What information would you need to know or understand in order to make decisions about X?
What do you think this shows?	What conclusions can you draw from the evidence available?
Why is this a controversial topic?	How do you think society's exposure to and comfort with the science behind X topic impacts their perspectives on the issues?
What do you think about X person who shares :: controversial perspective:: on this topic?	How do we go about determining the validity of a person's expertise in a subject area? If they are not an expert, how can we check that their contributions/information is valid?

Science and Engineering Practices

<u>Engaging in Argument from Evidence</u>

- Engaging in argument from evidence in 9-12 builds on K-8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to **defend and critique claims and explanations** about the natural and designed world(s). Arguments may also come from current or historical episodes in science.

- **Evaluate the evidence** behind currently accepted explanations or solutions to determine the merits of arguments.

Set up scenarios that help explicitly identify preconceived notions or misconceptions

- Have students write about what they know
  - T/F or multiple choice can mask misconceptions is students have some misunderstandings
- Make sure it is NOT assessed (pre-questions vs pre- ‘test’)
  - Helps to set up an environment where the point is what you LEARN not what you CAME IN WITH
- Be sure to come back to these later
  - People fall back on misconceptions unless they explicitly address and ‘fix’ them.

Provide avenues for evidence

- Present the data for analysis, or have them collect it on their own
  - Be constructivist: have them figure it out
- Have reliable, scientific, resources available for the scientific aspect
  - They need to learn the actual science to understand that perspective

Provide avenues for evidence

- Have reliable resources available that directly address the controversy (i.e. in psuedoscience)
  - Scientists, doctors, researchers, etc are starting to be more public in how they address inaccuracies and misconceptions
  - Teaching the actual science isn't the same as identifying the missing pieces of the non-scientific perspective or pointing out the 'bad' science or incorrect conclusions. **(Remember, you have to actually address the misconception!)**

Provide avenues for evidence

- Use student ideas:
  - As you ask students what kind of evidence they would need to form their ideas/make their decisions, be ready to help them find that evidence

  - You can likely predict these ahead of time, so be ready with resources. NOT just the texbook. Sources outside the traditional classroom mean more buy in and engagement from the students!

    - Use Education websites (or reliable informatinoal web pages)
    - Make friends with librarians who work with scientific literature databases (they are are amazing for search help)
    - Good 'news' science articles can be just as powerful or even more so than journal articles (Science Daily, The Scientist, etc)
    - Find a scientist in the field to ask.
    - Email me! I'll help you look. (More resources for me, too!)

Ask students to reflect:

(But don't just ask, MAKE them. They will not do this on their own effectively if you are just asking them to 'think about it'. Group discussion, short write, anything, but it must happen)

- What were your thoughts/ideas/ misconceptions/opinions at the beginning? What were those based on?

- How has your understanding developed based on what you have learned? (Be specific.)

- What questions might you still have?
  - This is especially important when there may not be a right answer and your focus is giving them the tools to make a more scientifically informed choice.
    - (i.e. should genetic modifications of animals be legal under particular conditions)
    - In cases like these there should ALWAYS be more questions

Ask students to Critique/Review

- Look at ‘popular’ news articles (especially if paired with scientific literature)
  - How well is the science represented?
  - Are the conclusions consistent with the actual research
  - What larger claims or implications did the news article make?
  - WHY do you think media often has this problem?
    - We discuss the attempt to simplify (to the extent it’s inaccurate) in some cases, as well as the need for sensationalism to attract readers.

Some Examples in Biology:

Evolution:

Addressing Preconceived Notions/ Misconceptions

- Pre-write
  - Scientific language
    - Theories
    - Laws
    - Hypotheses
    - Falsifiability
  - What's it about?
    - What do you think Evolution is? When I say Evolution, what comes to mind?
  - Evidence
    - How does evidence fit into your understanding

Provide Avenues for Evidence

Evidence for common ancestry:

- Identifying homologous structures
  - Defined as having:
    - Similar shape and make up- bone, etc.
    - Similar organization- where it's at in the body
    - Similar development- from embryo/early stage, how it forms
  - These characteristics support that they share a common ancestor

Provide Avenues for Evidence

Evidence for common ancestry:

- Identifying homologous structures
  - Show structures and have students identify potential homologous structures based on the criteria
  - Can use models or collected images
  - Go beyond bones:
    - Compare soft tissues (brains, etc)
    - Look at invertebrates, insects, etc.

Figure 4: Shown here are skeletons of a various animals with the human in front

Figure 1: Various vertebrate skeletons. The vertebrae are homologous structures.

Provide Avenues for Evidence

Evidence for common ancestry:

- Identifying Vestigial structures
  - Reduced in size and function (or totally lacking function), but similar to fully functional structures in other organisms
  - Best explanation is shared ancestry.

Figure 3: The human, horse, and pig leg are shown from left to right respectively.

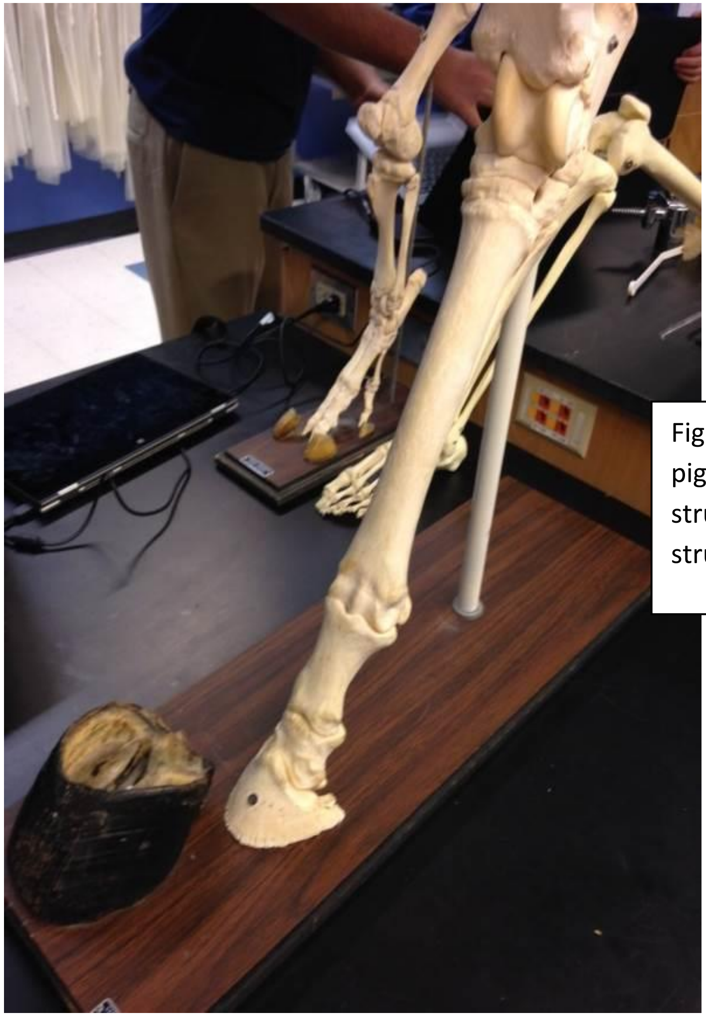


Figure 2: Horse leg, human leg, and pig leg. The horse has a vestigial bone structure. The legs are homologous structures.

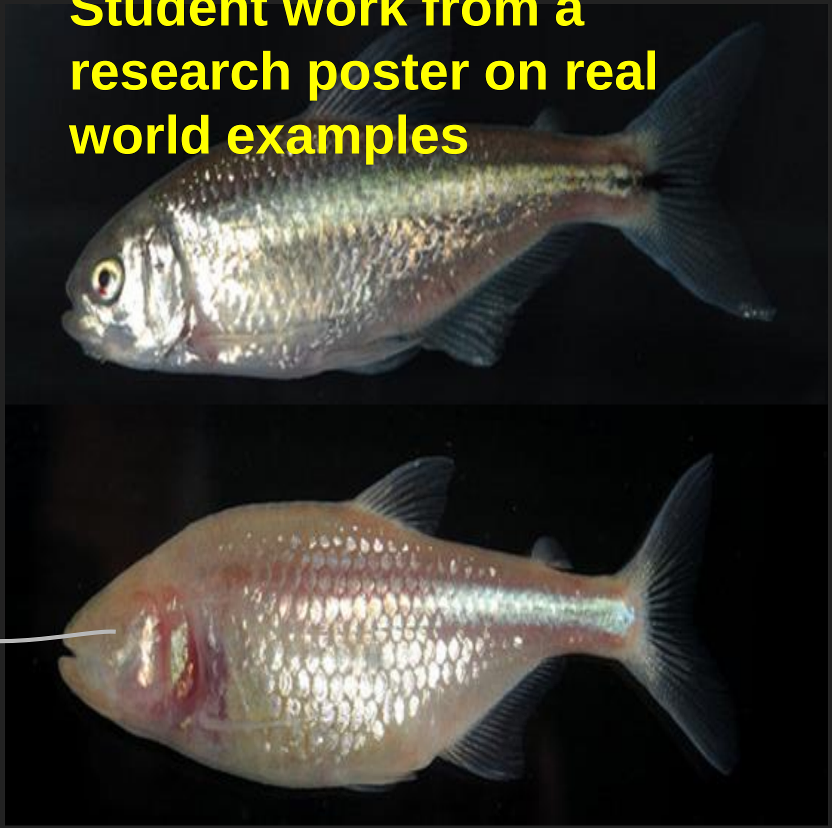
Vestigial Eyes and Pigmentless Bodies in *Astyanax mexicanus*

Introduction

There are two categories of the *Astyanax mexicanus*: the blind cavefish and the surface fish. Mutations in the blind cavefish were naturally selected to improve its fitness in the cave environment, thus diverging from its surface counterpart (Jeffrey 2003).

Vestigial Eyes

Because fish with good eyesight did not survive better than fish with worse eyesight in dark caves, they degenerated into vestigial structures. This also allowed the blind cavefish's other sensory organs to be enhanced, which benefit the cave animal more (Jeffrey 2003). The cornea, iris, and ciliary body do not develop, although neural crest cells migrate into the eye region (Jeffrey 2005). Plus, exposed eyes can get infected and damaged, so it is better they are hidden away.



Pigmentless Bodies

In cave environments, because there is no light, fish cannot see or be seen. Thus, having a pigment is a waste of energy, which could be put into other functions that better aid the fish in survival. Pigmentation improves survivability in a normal environment, with light, by attracting mates or blending into the environment to be safe from predators.

Works Cited

Jeffrey, W., Strickler, A., and Yamamoto,Y. (2003, Aug 1). *To See or Not to See: Evolution of Eye Degeneration in Mexican Blind Cavefish.* Retrieved from http://icb.oxfordjournals.org/content/43/4/531.long

Jeffrey, W. (2005, Jan 13). *Adaptive Evolution of Eye Degeneration in the Mexican B[illegible]ish.* Retrieved from http://jhered.oxfordjournals.org/content/96/3/185.full

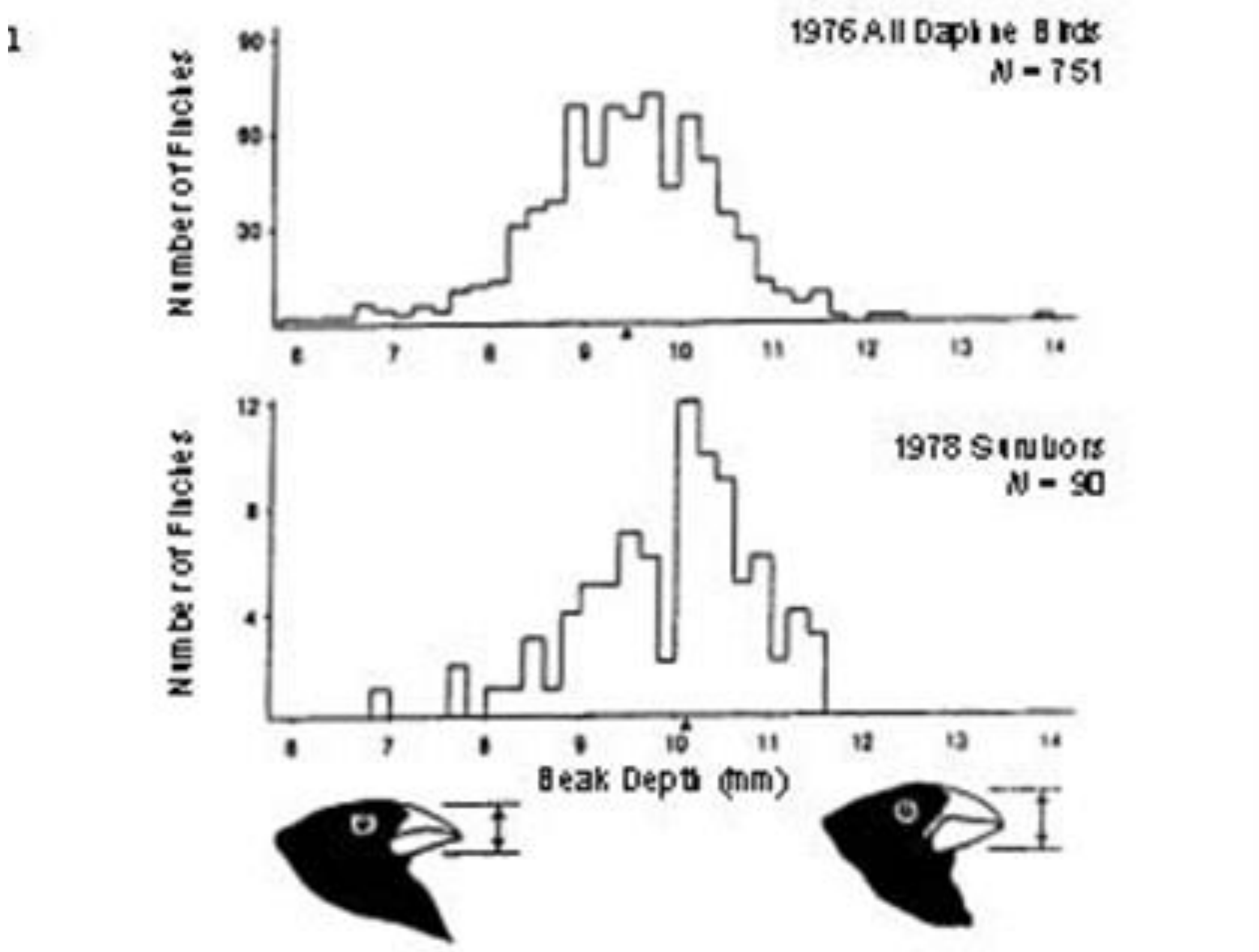
Melina R. (2012, Jan 23). *In Images: The Extraordinary Evolution of 'Blind' Cavefish.* Retrieved from http://www.livescience.com/18069-evolution-blind-cavefish-image-gallery.html

Provide Avenues for Evidence

- Evidence for mechanisms
- Natural Selection
  - Traits that are most beneficial for reproduction will increase in proportion over subsequent generations
  - Focus on fitness being more than survival or health (i.e. with sexual selection)
  - Link back to terminology: Natural Selection is a law (description)

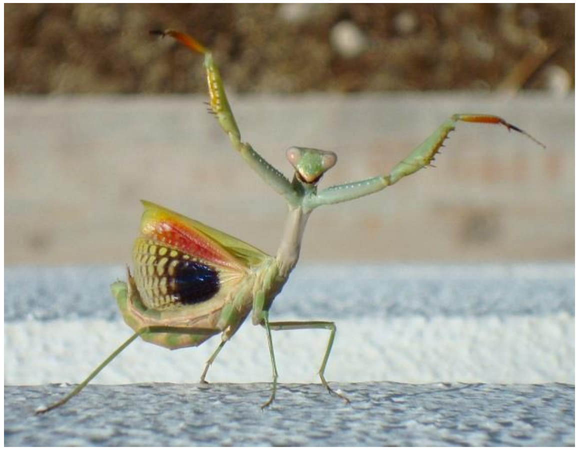
Peter and Rosemary Grant's work with Finches

http://www-tc.pbs.org/wgbh/evolution/library/01/6/pdf/l_016_01.pdf



Evidentiary Examples

- Special cases of Sexual Selection
  - Peacocks- tails
  - Silent crickets- parasitic fly finds them with sound; but chirping is a mating strategy
  - Praying Mantis-female cannibals



Smelly t-shirts

- The t-shirts that females most associated with associate mates were from males with dissimilar MHC complexes.
- Opposite true for association with family

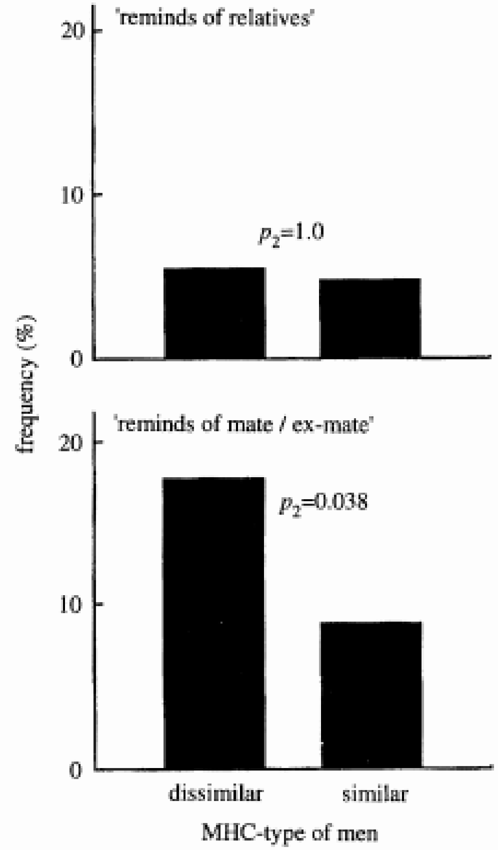


Figure 4. Frequency of women's memory associations by sniffing the odours of MHC-dissimilar men and of MHC-similar men with relatives, and with current or previous mates, respectively (Fisher exact tests, two-tailed). Most of the memory associations in the lower graph were by women who stated that they were sure they had not taken the contraceptive pill when they chose the particular mate they were remembered during the experiment (31 of total 39 cases, $Z = 3.68$, $p < 0.01$).

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http://www.coherer.org/pub/mhc.pdf

Provide Avenues for Evidence

- Evidence for mechanisms
- Mutation
  - Sequence data
  - Connect to DNA replication (errors) and Meiosis (passed on via gamete formation)
- Gene Flow
  - Pollen Transfer
  - Herds mixing
- Genetic Drift
  - Small populations
  - Bottleneck and drift in Cheetahs

Provide Avenues for Evidence

Evidence for mechanisms

- Simulation: (on digital commons)
  - Shows mathematical approach to evolutionary biology
  - uses colored beads to represent alleles/traits
  - Starts with genetic drift
  - Asks students to modify the procedure to represent other mechanisms
  - Gives a helpful model to understand/support understanding of change over time

Reflection

- Connect the dots: Drawing from what you've learned about the mechanisms of evolution, and what you've seen in the lab, demonstrate your understanding of Evolution as the overarching theory of biology. Be sure to include information on how it helps explain:
  - Similarities across many organisms
  - Differences between organisms
  - Different species
  - Characteristics/Traits prevalent in different environments
  - Etc

Genetic Information & Testing:

Genetic Information & Testing

- Content connections:
  - Gene Replication & Sequencing
  - Gene Expression (Transcription/Translation)
  - Regulation of DNA
  - Inheritance
  - Health & Disease
  - Connections to current technology

Genetic Information & Testing

- Addressing preconceived notions and current understanding. Have students consider:
  - What is the purpose of genetic sequencing?
  - How do we obtain genetic sequences? How challenging is it?
  - What are some potential advantages of obtaining genetic information for humans, from a scientific/ societal standpoint?
  - What are some disadvantages?
  - What sorts of privacy should be involved with genetic information? Who has rights to you information? Who makes decisions based on it?

Genetic Information & Testing

- History of Sequencing:
  - Human Genome Project
- How does sequencing work?
  - Sanger Method basics: Simulation activity (digital commons) – only need basics of DNA structure/function
  - Next Generation Sequencing Methods – these really demonstrate movement of technology (sequencing 10 years vs 10 hrs)
    - Ion Torrent : NGS

Genetic Information & Testing

- What can we predict with genetic information?
  - Inherited genetic diseases and risk factors for others
    - i.e. BRCA breast cancer screening, Alzheimer's, etc
- What are the limitations?
  - Being more likely to develop something does not mean that you will get it
  - Does not consider other factors, such as epigenetics or environmental influences.

Genetic Information & Testing

- What are current policies and regulations?
  - National Human Genome Research Institute: Genetic Discrimination
- What are current feelings on ethics, etc?
  - Future of genomics presentation (activity on digital commons)
    - Includes testimony to a House of Representatives sub-committee on health, by director of the National Human Genome Research Institute, Francis S. Collins

Universal Declaration on the Human Genome and Human Rights (UN)

A Human Dignity and the Human Genome

Article 1

The human genome underlies the fundamental unity of all members of the human family, as well as the recognition of their inherent dignity and diversity. In a symbolic sense, it is the heritage of humanity.

Article 2

a) Everyone has a right to respect for their dignity and for their rights regardless of their genetic characteristics.

b) That dignity makes it imperative not to reduce individuals to their genetic characteristics and to respect their uniqueness and diversity.

Article 3

The human genome, which by its nature evolves, is subject to mutations. It contains potentialities that are expressed differently according to each individual's natural and social environment including the individual's state of health, living conditions, nutrition and education.

Article 4

The human genome in its natural state shall not give rise to financial gains.

Genetic Modification:

Genetic modification

- Content connections:
  - Gene Expression (Transcription/Translation)
  - Regulation of DNA
  - Inheritance

Genetic modification

- Addressing preconceived notions and current understanding. Have students consider:
  - Why do we seek to genetically modify organisms?
  - How does genetic modification work? What sorts of gene regulatory components would need to be considered?
  - What are the benefits of genetic modification (from scientific standpoint)?
  - What are the benefits of genetic modification (from societal standpoint)?
  - What are the potential risks/drawbacks of genetic modification (from a scientific standpoint)?
  - What are the potential risks/drawbacks of genetic modification (from a societal standpoint)?

Genetic modification

- Discuss how genetic modifications work:
  - Basic example: recombinant insulin
    - How insulin is made (DNA Learning Center)

  - Relate to gene expression/transcription
  - Relate to inheritance (how the modification can be passed to other cells via mitosis or other organisms via meiosis)

Genetic modification

- Mores examples:

  - Gene therapy to cure blindness
    - Inserted into the eye to regrow cells
    - Fades over time, but can restore a large proportion of vision

  - Genetic Therapy for Cystic Fibrosis
    - Inhalant of powder containing functional copy of gene

Genetic modification

- Current example: CRISPR

  - How it works:
    - How CRISPR Works
      - Use of microbial viral defense mechanisms to modify genes in living cells.

  - In the (scientific) News:
    - Genome Editing for Xenotransplantion (pig organ transplants)
    - UK scientists seek permission to edit human embryos
    - Genome Editing in Embryos is Essential
    - Wired: America Needs to Figure out the Ethics of Gene Editing Now

Genetic modification

- Current example: CRISPR
  - <u>Implications:</u>
    - Have students first focus on the science:
      - What can we do with this from a research and medical standpoint?
        - What can we learn?
        - What can we do to help improve lives?

Genetic modification

- Current example: CRISPR

  - Then discuss the societal implications

    - What are some potential question or issues that may arise from this technology in society?

    - Where do we draw the line of what modifications are ok (medical treatment, etc) and which are not (choice characteristics)

Genetic modification

- Current example: CRISPR
  - Remember to focus on the evidence, not opinion
  - Help students develop the right questions that THEY would need to have answered to formulate decisions, etc.
  - Relate to what is already being discussed/debated/etc in the scientific community
    - ***Many, many sources and voices from the field on this issue***

Ethical Implications of Genetic Information & Genetic Modifications

- Presentation in an ethics seminar series @ IMSA on digital commons:
  - Issues in Modern Genomics
    - Created w/ senior seminar students
    - Contains many more examples of discussion topics and current science
    - Found @: Digital Commons: Considerations in Ethics

Other Examples

- Vaccines
  - Good example of how research is revisited, re-tested, and conclusions overturned (vaccines & autism) based on further testing and evidence
- Food Safety
  - Misconceptions about dosage (used for testing vs normal consumption in foods)
  - Misconceptions about natural vs synthetic (natural does not mean safe, etc)

Other Examples

- Alternative Medicine
  - What criteria must it meet to become mainstream medical practice
  - What are limitations in terms of medical testing
  - What misconceptions do people have from a scientific standpoint that supports some of these?
    - Examples: changing body pH for better health, supplements that have questionable cause/effect health impacts, etc.
    - * Good place to have students look for evidence!

Other Examples

- Climate Change
  - Other presentation has many resources for this on digital commons
  - Start with the science of biogeographical cycles and how different variables impact them
  - Relate to real world examples and their implications
- Ecosystems Destruction and Extinctions
  - Resources for this available as well
  - Provide examples, data, etc.
  - Have students discuss the benefits and drawbacks of saving ecosystems (preserved habitat vs use of land for humans, etc)
  - Good places for creativity: ideas for how address concerns and mitigate outcomes

Key Reminders:

- As you use these specific examples, remember to help students focus on
  - What differentiates addressing content from the scientific standpoint from viewing it from other perspectives (ethical, societal implications, etc)
  - What kinds of questions need to still be answered, as scientists, or as individuals as a part of society to draw conclusions and make our own decisions/opinions

Key Reminders:

- As teachers we should strive to :
  - Focus on the science
  - Be a guide and help our students build the skills to find answers
  - Plan ahead so that we are more confident with questions/controversies that arise
  - Reflect on our own perspectives as scientists, teachers, and individuals, and how our ‘dragons’ may influence how we teach
  - Be comfortable learning and questioning with our students; it’s ok to have the same questions that they do about the future.

Thank you!

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