Nuts and Bolts of Evolution

Summary

Through activity, lecture/discussion and a paragraph summary, students will understand that imperfections in organisms are an evidence for evolution. They will relate this to changes of populations over time and explain them by evolutionary process.

Time Frame

1 class periods of 70 minutes each

Group Size

Small Groups

Materials

- adaptation chart for overhead
  (attached)
  blocks of wood (any size/shape/type work)
  screws or nails

Background for Teachers

Safety Issues:
Students should be careful with the blocks and screws. They should be sure not to damage tables, floor, books etc when trying to get their screw/nail in the wood. CAUTION students against doing anything that might cause damage or injury to anyone or anything.
Duration: 1 ½ class periods (70 min.)

Student Prior Knowledge

Students should understand inheritance and environmental pressures for evolution. They should also understand the definition of evolution.

Instructional Procedures

Distribute wood blocks and screws (and/or nails), one of each per person
Tell students that their job is to get the screw (or nail, note: screws are more difficult) as far into the block as they can, using any object or device (other than a real tool) that they can.
CAUTION students against doing anything that might cause damage or injury to anyone or anything. DO NOT offer any suggestions as to how they might get the screw (or nail) into the block of wood.
Students will begin to find ways to accomplish the task, such as using fingernails, or coins, or some other object to twist in the screw, to simply hammering it in with heel of shoe or something else, or by banging it on the table or floor (if you see this, be sure they are not damaging the surfaces).
After about 5 minutes of this (or less if you can't handle the noise), stop them (at whatever point they are in accomplishing the task). Ask some questions, such as "How many got the screw all the way in?", "How did you do it?" (ask this several times, to get several different strategies and several different kinds of items they used to help).
After several items have been named, ask if that was the originally intended use for those objects (no), and ask if they worked as well as a screwdriver would have worked (no). (If someone happens to have and uses a screwdriver, e.g. on a key chain, remark about how well

prepared that person is, but otherwise ignore that tool for now).
Point out that these are examples of "contrivances", objects used, or modified, to do something clearly very different from what they were normally used for, and typically not highly efficient. There are many examples of natural contrivances and other "imperfections" in living organisms, even humans.
Set up 4 columns on the chalkboard or overhead projector, headed as follows (you may want to omit the vocabulary name for each column for now, and add it later, after some examples for each are listed):
Point out that, in living organisms, an "adaptation" can often be traced to a structure which served a different function in earlier species (and may still serve that function in other living species), so in a sense, an adaptation can be traced to a contrivance of an earlier time. We can tell that they were contrived from something else from studies of their embryos, the fossil record, and their comparative anatomy with similar organisms. A good example is the wing of a bird, or the wing of a bat.
More obvious contrivances are often less efficient, even awkward, typically still resemble their original structure, and are not "perfectly" adapted to their new job; they are adaptive compromises. Some are obviously re-tooled versions of other structures. Many clearly show their contrived nature; they are really poor (and hardly ideal) design solutions. They seem to challenge the popular notion that all living things are the product of intelligent design. We call these "contrivances", or sometimes "imperfections" since they clearly are imperfect. a good example would be the radial sesamoid wrist bone of a panda being used as a sixth digit "thumb".
Another class of imperfections (and therefore poor design) makes its appearance in the form of structures with no clear function, often reduced in size from their counterparts in other (or earlier) species. The origins of these, too, can be traced through their comparative embryological and evolutionary development. If these reduced features commonly appear in all or most individuals, we call them "vestigial" structures (example: our "wisdom" teeth). If they appear only rarely, they are called "atavisms" (example: tail on newborn human). If you like, you could add the term "imperfections" to encompass the last 3 categories.
Ask students to suggest examples for each category. They can start with items used for getting the screws into the blocks. Then try to think of examples in living things. If students have trouble here, suggest the following examples:

Work together in small groups, listing as many examples as they can in each column. Do this for about 10 minutes.

Call for examples (by column), one from each team in turn. Add these to the lists, as appropriate. Students may challenge items (wrong column, or totally inappropriate), but they must give reason for the challenge. Rotate through all teams several times, until they run out of examples, or class time is about to run out.

Display the transparency of the list provided below. Uncover one example at a time. This should help supplement the student contributions. Be sure to point out examples already submitted by your class. For each item, as it's revealed, ask the class to assign it to one of the 4 categories, and so check it. Continue until you feel enough examples are presented.

In conclusion, point out that we find all degrees of imperfection, from incomplete features appearing sporadically (atavisms), to some features causing real survival difficulties or being reduced to non-functional status (vestigials), to some features being clearly but incompletely contrived from other structures (contrivances). This suggests a long time element in the formation of these structures. We would not expect such imperfections in a process of instant "special creation". Time and imperfections are exactly what we would expect in the gradual process of evolution. Therefore, the existence of imperfections in living things provides very

compelling evidence of evolution.

Have students write a paragraph explaining how imperfections are evidences for evolution. They should relate the definition of evolution and also note what molecular processes allow for the imperfections. They should also explain the role the environment may play in this process by using at least 2 examples that were discussed in class.

Answer Key to Table:

SOME ADAPTATIONS & IMPERFECTIONS

- *Our spinal column, clearly homologous to the "suspension bridge" support structure in tetrapods, must serve as a vertical load-bearing column in people, bringing an abundance of classic back problems when its support is compromised. (CO)*
- *Our Eustachian tube (ear canal), homologous to a gill cleft in fishes, serves to equalize air pressure on opposite sides of our eardrum. Small changes in air pressure (due to altitude change, or other cause) can bring severe ear pain, especially if the tube is swollen closed due to a cold, and is often subject to infection. (CO)*
- *Human tail: Always on our embryo (VE). Sometimes, babies are born with a fleshy tail (AT).*
- *Our "wisdom teeth" (3rd molars), sometimes never develop, often become impacted, may require surgical removal. Is this "wise design", or the unfortunate result of reduced facial projection as the teeth reduced in size over the course of human evolution? (VE)*
- *Our ear-wagging muscles. (VE)*
- *Sickle Cell Anemia: caused by a molecular mechanism which, in a moderate (heterozygous) dose, protects against malaria, but in its full dose (homozygous recessive), produces disabling disease of sickle cell anemia. (CO)*
- *The flippers of seals and sea lions are clearly homologous to the legs of tetrapods, and work quite well in the water, but make for very clumsy locomotion on land. (CO)*
- *Tree kangaroos show limited adaptations of their limbs to their arboreal existence, but they're still relatively clumsy in the trees, and they are also not as fit for activity on the ground as their ground-dwelling relatives. (CO)*
- *Anteaters develop teeth during fetal development and then lose them before birth. (VE)*
- *Terrestrial salamanders develop gills and fins but only during fetal development. (VE)*
- *Flying birds possess hollow bones. (AD)*
- *Flightless birds (e.g. ostriches, moa, emus, penguins) also possess hollow bones. In terrestrial birds, hollow bones cannot provide nearly the structural support found in other terrestrial vertebrates.(VE)*
- *Many cave-dwelling animals possess sightless eyes. (VE)*
- *Male booby birds court females with nesting material then mate with them, throw the nesting material away, and the females lay their eggs on the bare ground. (VE)*
- *Some beetles have useless wings sealed beneath wing covers (elytra). (VE)*
- *Certain whales sometimes possess a pelvis and thigh bones. (AT)*
- *Some baleen whales have teeth (embryos only) (VE)*
- *Pythons and boa constrictors possess a pelvis and tiny limbs. (VE)*
- *Panda's thumb: sixth "digit" formed from a wrist bone. While it is functionally a digit, it is structurally different from the digits of all other mammals. (CO)*
- *Extra toes found occasionally on horses: Usually duplicates of the main (3rd) toe, but sometimes they develop from the enlarged "splint" bones (vestigial toes 2 and 4). (AT)*

REMEMBER, THE EMPHASIS HERE: Notice the MANY IMPERFECTIONS in living things (not so

much their categories the definitions are not as important); are these most likely the result of poor design, poor engineering, or normal evolution?

Bibliography

Lesson Design by Jordan School District Teachers and Staff.

Authors

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