The Evolution Game

SUMMARY

Functionality is the essence which biomimics seek to emulate from nature, for example how the structure of gecko feet allow it to climb walls without using glue or how termite mounds regulate temperature without external energy. In this game, students learn about the processes of evolution, natural selection, and ultimately, how adaptation leads to functionally advantageous design. Theoretically, students will be competing for food while using the concept of adaptation. In this activity, students will modify a piece of paper each round and try to reach a target in the fewest number of throws. Reaching the target in fewer throws illustrates the process of refinement through generations of time and aids in survival for the organism.

GOALS

- Students will learn about the process of natural selection
- Students will learn how innovation in nature leads to functionally advantageous design

OBJECTIVES

- Students will recognize species have to adapt in order to survive
- Students will learn that organisms are subject to environmental conditions and that these conditions largely impact how the organism adapts
- Students will learn how adaptations developed through natural selection can lead to superior functional performance.

MATERIALS

-Half as many paperclips as there are students
-Regular typewriting paper (about two times as many pieces of paper as students)
-Box for paperclips
-Geological Evolutionary Timeline (compressed into a shorter time frame, e.g., one day, one calendar year, etc.)

This lesson plan was produced collaboratively by The Biomimicry Institute (www.biomimicryinstitute.org) and The Montana Natural History Center (www.montananaturalist.org).

BACKGROUND INFORMATION

Biomimicry is an approach to technological innovation that draws its ideas from nature to solve the greatest environmental challenges of our time. Energy efficient buildings inspired by termite mounds, resistance-free antibiotics inspired by red seaweed, and non-toxic adhesives inspired by geckos are examples of biomimicry. The premise underpinning biomimicry as a green innovation tool is that nature has nearly 4 billion years of technological innovation and refinement embodied in 10-100 million species, and has already sustainably solved a vast array of the same technological challenges facing humanity, so that it should be an extremely fertile source of green technology solutions from which humanity can learn. This lesson about evolution is important for many reasons, and in the context of learning about biomimicry, is important because it is the premise underlying biomimicry's approach to technological innovation.

VOCABULARY BOX

Natural selection: process by which favorable heritable traits become more common in successive generations of a population of reproducing organisms, and unfavorable heritable traits become less common.

Adaptation: An adaptation is a positive characteristic of an organism that has been favored by natural selection and aids in survival.

Function: In biology, functions describe what a characteristic or process does or how it performs, within the context of natural selection and the imperative to survive and reproduce. As such, discussions of function seek to explain why an object or process occurs in an organism or system upon which natural selection has acted, and is closely related to the term 'adaptation', which is a functional characteristic of an organism. More generally, function refers to the purpose or operational result of any mechanism, so that we can speak of parallel functions that exist in both the natural and human-built worlds, for example, adhesion in geckos and in human-made products like medical bandages.

ACTIVITY

THE EVOLUTION GAME

DURATION: 30—45 minutes

PROCEEDURE- -

1. Hand the students each a piece of paper.
2. Next rearrange the classroom so all students can stand in a large circle around a box of paperclips placed in middle of the classroom. The objective of the game is to glide the paper towards the paperclip box until it touches it.
3. Before the first round, the students may bend or fold the paper in any manner they wish, if any, as long as they glide their piece of paper (e.g. they cannot crush their paper into a ball for throwing). Note: Students cannot change their paper in the middle of the round.
4. Now have the students throw their pieces of paper toward the box and have them keep track of the number of throws it takes for their paper to touch the box.
5. For every paper that touches the box, the student takes a paperclip out until paper clips are gone. As the students reach the paperclip box they will probably interfere with the other players throws. The students still throwing must still count this as a throw; in other words there are no redos.
6. At the end of the first round (when all paper clips have been taken), the teacher explains that the papeclips are like food and that the organisms who found the food first survived, while the other organisms went extinct.
7. The students that do not receive paperclips did not survive and will now be observers to the rest of the game.
8. The students who received a paperclip tell the teacher to record their name and number of throws for each round.
9. All paperclips are returned to the box for the next round. The instructor then takes half of the paperclips out of the box.
10. The remaining students reposition themselves in a large circle around the paperclip box, and are told they may modify their paper again, if desired, in any way they feel will improve their chances of gliding their paper to the paperclip box in a fewer number of throws.
11. Then, the process repeats itself. The students who received a paperclip tell the teacher to record theirscores. The students who are out of the game should observe the strategies and modifications of the students who are able to touch the box in fewer throws every time.
12. After an appropriate number of rounds, the teacher asks the children what the game reminds them of. The teacher then discusses how the game is like evolution and explains that this is what happens in life: generation after generation, the organisms that survive (i.e. get paperclip food) have offspring (i.e. survive to new rounds) and those offspring which survive best have offspring, and so on, each generation being similar to the parents, but generally improved or refined over time.
13. The teacher asks the children that survived the most rounds of the game to show their pieces of paper and explain how they modified them each round to improve their performance. Then the teacher also asks the students sitting out of the game if they noticed any other strategies used by players. For example, the students who got to the box in fewer throws were better adapted and perhaps had a little bit of luck. But because they got there first, the other organisms may have had a harder time finding a direct shot because of interference. Students may have adapted their behavior by waiting to throw their paper at a relatively calm moment.
14. The teacher points out other patterns and anomalies in the folded papers and asks students where their design inspiration came from.
    a. For example, a student who didn't want to modify their piece of paper could have

ACTIVITY

reached its optimum. For example, many organisms such as sharks and cockroaches have such a good design that they can withstand diverse environmental pressures and consequently have remained the same for millions of years.

b. If the game is conducted outside, the teacher can point out how organisms are directly subject to environmental conditions. If the wind is blowing the student might have to adjust their strategy. If an organism lived in a windy environment they may have developed a unique shape and structural characteristics to adjust to wind. For example, many plants have adapted to windy environments by exploiting it with long, flat appendages, light weight, etc.

C. Students will most likely mimic each other as well, learning from those who have adapted well. Mimicry is also common in nature, such as how some flies mimic the look of bees, etc.

15. Next, have all the students' line up their pieces of paper of all different shapes to show the diversity of organisms and explain how the process of natural selection causes this diversity. Indeed, we are not even certain how many species exist on Earth, but the estimates generally range from 10 to 100 million.
16. The teacher can point out that each of these species embodies 3.85 billion years of trial and refinement, so that we see in nature not only a vast diversity of innovations, but that each innovation is highly refined or optimized. Hand out the geological time scale for bet-

EXTENSION

- ◊ Link to lesson showing how evolution is why we can learn so much from organisms.
- ◊ Link to Designer Animal lesson

CONCLUSION AND DISCUSSION

- ◊ The teacher can then make the point that this process of refinement which characterizes evolution happens at many levels (not just shape).
- ◊ Brainstorm with class varying functions that organisms need to be able to do and how they solve these problems (e.g. avoid predators, fight infection, and convert food into energy, etc.)
- ◊ Questions: Does anyone have any examples of organisms that have evolved over time and how they have evolved (someone might mention Darwin's finches, etc)?
- ◊ Mention biomimicry briefly: Many of these functions are similar to functions and problems humans are trying to solve, such as creating adhesives, antibiotics, or solar energy devices, etc. Moreover, each of these organisms ha solved these problems in a sustainable way, so that we stand to learn a lot from the natural world about how to solve the technological challenges facing us, and to do so in a sustainable way. Indeed, there is a whole approach to science and innovation called biomimicry, which consciously attempts to emulate Life's genius in human design.
- ◊ Inform the class that they will be learning more about this concept in the next classes.

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