HOW TO DO IT

Using Card Games to Simulate the Process of Natural Selection

NABT BioClub RECOMMENDATION

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ABSTRACT

In 1858, Darwin published On the Origin of Species by Means of Natural Selection. *His explanation of evolution by natural selection has become the unifying theme of biology. We have found that many students do not fully comprehend the process of evolution by natural selection. We discuss a few simple games that incorporate hands-on activities to demonstrate to students this important aspect of biology.*

Key Words: *Evolution; natural selection; card games; lab activity.*

Evolution is one of the fundamental themes of biology (National Academy of Sciences, 1998; Battisti et al., 2010). To understand biology, it is important for students to understand evolution by natural selection. Unfortunately, research has shown that many high school students have misconceptions about evolution and that these misconceptions persist into the college years (Demastes et al., 1996; Anderson et al., 2002; Battisti et al., 2010). Thus, there is a need to develop new methods to teach the concepts of evolution to students.

To understand biology, it is important for students to understand evolution by natural selection.

Hands-on laboratory experiments can help students develop more positive attitudes toward science and increase their knowledge of scientific content (Freedman, 1997). Our experience with college students has shown that hands-on laboratory experiences are a great way of reinforcing ideas presented in the classroom. For this reason, we have developed a lab activity that uses modified versions of familiar card games to simulate the process of natural selection. We suggest that these simple games can help high school and college students achieve a proper understanding of the theory of natural selection and help them overcome misconceptions regarding the theory of evolution.

The lab activity begins with a general introduction about the process of natural selection. Most high school and college students are familiar with Charles Darwin and his theory of evolution. However, most students cannot explain more about natural selection than the catchphrase "survival of the fittest." In our activity, games allow students to visualize the process of natural selection as it occurs in different ways within populations (i.e., directional, stabilizing, and disruptive). We used familiar but modified card games to investigate three specific types (directional, stabilizing, and disruptive) of natural selection.

There are several learning objectives in this lab activity. At the end of the activity, students (with guidance from instructor) will be able to (1) identify the type of selection represented by each game, (2) explain the random nature of variation as well as the nonrandom nature of differential survival, and (3) describe how natural selection leads to changes in populations.

Game 1

Students working in pairs play a modified version of the children's card game "War." A deck of cards is needed for each player in the game. The cards represent proportions of the population, not actual numbers. For example, in a normal deck, Kings represent 1/13th of the total population (4 Kings out of 52 cards). Thus, in these experiments, as the deck gets smaller, do not infer that the population of organisms is also shrinking. Assume that the number of organisms is stable (at perhaps 1 million), and the only thing that is changing is the proportion of different organisms. For example, if there are only 10 cards in the final deck, and 1 of those is a Jack, then Jacks make up 10% of the total population. We provide a hypothetical example in the first column of Table 1.

1. Each player shuffles his/her deck.
2. Place the cards face down.
3. Each player flips over the top card of his/her deck.
4. The player with the higher card wins the match (the Ace is the highest card in the deck). Each player will create a "live" pile and a "dead" pile. The winning card goes in the winner's live pile, and the losing card goes in the loser's dead pile. For example, let's say that player A flips over an 8 and player B flips over a Jack. Player A will put the 8 face down in his/her dead pile, and player B will put the Jack face up in his/her

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live pile. On the next turn, player A flips over a King and player B flips over a 10. Player A will put the King face up in his/her live pile, and player B will put the 10 face down in his/her dead pile. (Note: Players never exchange cards; they create their own live and dead piles.) In the event of a tie, both cards go in the live pile.

5. The cards in the dead pile failed the competition and therefore died out.
6. The player who finished the deck first ends the round. (Note: After the first round, you may notice that one player has more cards than another. This is not a problem. The player with the extra cards gets to place them in his/her live pile.) After this occurs:
   (a) Each player puts the cards from his/her live pile in order from 2 to Ace. (Do not combine or exchange cards with your partner, and keep your dead pile.)
   (b) Count the total number of live cards.
   (c) Count the number of each type of card (i.e., how many 2's, 4's, Jacks, and Aces). Fill in the table (see Table 1 for format) after you complete each round.
7. Each player reshuffles his/her live pile.
8. Repeat the process two more times, following the rules outlined in steps 2–8.
9. The cards remaining in each player's final live pile represent the organisms most fit for their environment.

Instructors can use Table 1 as an example to explain how to calculate the percentage and the population. Students play the game and complete the remaining four rounds. You can see that the player ended up with 25 cards in his/her live pile. The player ended up with zero number 2's in his/her live pile. Therefore, percent 2's = 0/25 or 0%, and there would be zero 2's in the population. The player ended up with four Aces in his/her live pile. Therefore, percent Aces = 4/25 or 16%, and there would be 16% of 1 million or 160,000 Aces in the population. (Note: The total percentage should add up to ~100, and the total population should add up to ~1 million, depending on rounding.)

○ Game 2

In this activity, we ask students how the results of Game 1 (War) would change if we modified the rules of the game. For example, would the final outcome be different if Aces and Deuces were the high cards? It may help to have students play the game again with the new set of rules. At the end, students can compare the results of Games 1 and 2 and visualize how the distribution has changed. By changing the rules of the game, we show and explain to students that although variation is random, selection is not. In other words, at the beginning of each game the different cards (i.e., 13 ranks) represent the variation present in the population. However, specific cards are winners (i.e., live) and specific cards are losers (i.e., die). After several rounds, students clearly see that certain cards (i.e., ranks) have a selective advantage.

○ Game 3

Students demonstrate natural selection by playing a modified version of blackjack (or "21") against a lab partner. They complete a table following the same instructions outlined in Game 1. Put the winning card in the live pile. For example, a 6 is worth six points. Play through the decks three times, using only the live decks in rounds 2 and 3.

1. Each player needs to shuffle his/her deck.
2. Place the cards face down.
3. In this version of blackjack, each player has one "hypothetical card" showing that is worth 12 points. (Note: Each student

Table 1. Format for Game 1 and 3 tables: # = number of each card of that value remaining in the deck, % = number of each card divided by total number of cards (e.g., 1/10 = 10%), and Pop. = percentage × 1 million (assuming a fixed population). The example column is from a hypothetical round of Game 1.

Card	Example			Round 1			Round 2			Round 3		
	#	%	Pop.	#	%	Pop.	#	%	Pop.	#	%	Pop.
2	0	0%	0									
3	2	8%	80,000									
4	1	4%	40,000									
5	2	8%	80,000									
6	3	12%	120,000									
7	0	0%	0									
8	1	4%	40,000									
9	2	8%	80,000									
10	2	8%	80,000									
Jack	3	12%	120,000									
Queen	3	12%	120,000									
King	2	8%	80,000									
Ace	4	16%	160,000									
Totals	25	100%	1 million									

can use the Joker as his/her 12-point card. We have each student use a sharpie marker to write 12 points on the Joker. This is the hypothetical card.)

4. Each player will flip over the top card of his/her deck. Remember that the point values for face cards are 10, the Ace is worth 1 or 11, and the number cards are worth their total.
5. The player who finishes closest to 21 without going over wins. For example, if player A flips up a 6, then he will have the Joker (i.e., 12 points) plus 6 = 18. If player B flips up a Queen, he will have 12 + 10 = 22. Therefore, player A wins and player B loses.
6. As in Game 1, each player will create a live pile and a dead pile. The winning cards go in the winner's live pile, and the losing cards go in the loser's dead pile.
7. In case of a tie, both of the players put their cards in their respective live pile.
8. If both players go over 21, both cards go in their respective dead pile.
9. The player who finished the deck first ends the round. (Note: After the first round, you may notice that one player has more cards than another. This is not a problem. The player with the extra cards gets to place them in his/her live pile.) After this occurs:
   (a) Each player puts the cards from his/her live pile in order from 2 to Ace. (Do not combine or exchange cards with your partner, and keep your dead pile.)
   (b) Count the total number of live cards.
   (c) Count the number of each type of card (i.e., how many 2's, 4's, Jacks, and Aces). Fill in the table (see Table 1) after you complete each round.
10. Each player reshuffles his/her live pile.
11. Repeat the process three more times, following the rules outlined in steps 2–8.
12. The cards remaining in each player's final live pile represent the organisms most fit for the environment.

○ Teacher Notes

There are several ways to ensure that the game runs smoothly and that students get the most from the experience. We have found that it is helpful to run a practice round after the instructor has introduced the lab. At the end of the practice round, the instructor can explain how to calculate the percentage and population. To clear up possible student misconceptions, please stress that the population size is fixed (which could provide a springboard to discussing carrying capacity of an environment). The change is to the variation within the population. It is best to have two different styles of cards, such as one red set and one blue set, for each pair of players. This makes it easier to sort the cards if players accidentally exchange cards.

○ Student Assessment Questions

Game 1

- Compare the percent Aces in the final live pile with that of the original stack of cards (i.e., the 52-card deck). Explain your results.
- Compare the percent Hearts in the final pile with that of the original stack. Explain your results. (There should be no change, because suit was not part of the selection process.)

Game 2

- Did changing the rules of the game affect the outcome? How is your final population different than it was in Game 1? Why do you think this happened? (Note: Guide students to explain that variation is random, but selection is nonrandom.)

Game 3

- Which card dominates the winning deck? Explain.
- Is this different from the final deck found from playing War? Explain.

General

- What form of natural selection did experiment 1 demonstrate? Explain.
- What form of natural selection did experiment 2 demonstrate? Explain.
- What form of natural selection did experiment 3 demonstrate? Explain.
- If we made Hearts high, would that change the final composition of cards in experiment 1? If so, how?

○ Discussion

As teachers, we have to find better ways to promote learning and present material in a way that students can comprehend. These natural selection card games were added to our lab schedule in 2010. This lab has been taught in all our classes by several different instructors. With guidance from the instructor, students visualize how the process of natural selection works. This lab is practical for high school and college biology students because a difficult biological concept is taught using simple games. Furthermore, the games can be played with limited space, and the lab materials are inexpensive. We have found that students have a better understanding of the process of natural selection at the conclusion of this lab.

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