

A Quick and Simple Natural Selection Role Play

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Abstract

Teaching evolution remains a challenging task in biology education. Students enter the classroom with stubborn misconceptions and many traditional examples of the process of evolution may not resonate with students. This short role play activity is designed to easily integrate into any class session on evolution and provide students with a concrete, tangible example of natural selection. In addition, it specifically addresses several misconceptions about evolution. In this activity, students become a fictional population that is under a selection pressure. As students take on the role of a population, they are reminded of the requirements for natural selection, fall victim to a selection pressure, and observe the change in allele frequencies over time. In the context of a class session that focuses on the mechanisms of evolution, students are able to immediately visualize the process of natural selection. This role play only takes 10-15 minutes, requiring minimal class and preparation time. It has been successfully used in both introductory and non-majors' biology classrooms. Though simplified and fictional, this role play provides a concrete example as a foundation for students' growing understanding of evolution.

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Supporting Materials: Supporting Files S1. Natural Selection Role Play – Intro Slides; S2. Natural Selection Role Play – RP Slides; and S3. Natural Selection Role Play – Answer Guide.

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Learning Goals

After completion of this activity, students will:

- Understand the requirements for natural selection to occur in a population
- Understand how natural selection impacts allele frequency in a population
- Refute common misconceptions regarding evolution and natural selection

Learning Objectives

After completing of this activity, students will be able to:

- Explain how natural selection impacts allele frequency in a population
- List and describe the four requirements for natural selection to occur in a population
- Refute common misconceptions regarding evolution and natural selection

INTRODUCTION

Evolution is one of the five core concepts of biology outlined by the American Association for the Advancement of Science (AAAS) (1). This concept is central for understanding the foundations of biology and the origin of the biodiversity of our planet. However, many students struggle to develop a firm understanding of evolution and often cling to common misconceptions (2,3). These misconceptions may be even more pervasive in introductory students and non-majors who have not had extensive exposure to evolutionary biology (2). Therefore, it is essential to begin addressing these misconceptions early, establishing a firm foundation of the processes of evolution in introductory biology courses and in non-major classrooms.

Numerous excellent activities exist to engage students in the understanding and mastery of evolution. However, many of these activities use extensive role play or games which may be daunting to an instructor inexperienced in active-learning or require too much time and forethought for a busy instructor. In addition, some of the existing role play activities require

props, computer access, or extended periods of class time (4,5,6). While these activities provide excellent opportunities for students to engage with the process of natural selection, the role play described here distinguishes itself as a flexible, quick, and easy to integrate activity. Since this activity doesn't take much time and requires minimal preparation and props, it should be an easy addition to any class session on evolution and natural selection, regardless of the instructor's experience or comfort level of using active learning and available class time. The approach is simple; it should engage the whole class in a low-stakes way.

This activity is a quick and simple role play where students become a fictional population of organisms undergoing natural selection. Several misconceptions are directly addressed, including that natural selection and evolution are the same process and that all individuals in a population evolve simultaneously. In addition, it builds student confidence in explaining the process of and the requirements for natural selection. After completion of the role play, a short minute paper provides an opportunity for students to retrieve and

reflect on the process of natural selection. This role play population becomes a common example the instructor can return to throughout the remaining lesson or unit on evolution. Students also appreciate the activity as a tangible memory they can return to when studying. Though simplistic, this activity provides a foundation that can be built upon with ‘real-world’ examples and more nuanced understanding of the evolutionary process.

Intended Audience

This activity has been used in both a non-majors and introductory biology course. It could also be easily integrated into a high school or AP biology lesson. It is meant to familiarize students with the process of natural selection and not necessarily dive deeply into this mechanism. Additional class discussions can provide deeper context and more details regarding this process using the role play as a common-ground example. This activity was originally used in classes of 20-30 students.

Required Learning Time

The role play itself only takes about 10 minutes with an additional five minutes for individual or group reflection. It was originally part of a 50-minute class period focused on the mechanisms and misconceptions of evolution. The role play occurred after some introduction to the mechanisms of evolution and the process of natural selection and was followed by further information about the mechanisms and misconceptions of evolution.

Prerequisite Student Knowledge

Students should be introduced to the basic definition of evolution, the mechanisms of evolution, and the criteria for natural selection. This can all occur during the class session in which the activity is used. This activity has been used in the first lecture on evolution to kick-off a unit on evolution and therefore does not assume any prior knowledge of evolutionary processes. Basic understanding of genes and alleles is required, but could be explained during the introductory material.

Prerequisite Teacher Knowledge

The instructor should be comfortable with the process of evolution, the four main mechanisms, and the process of natural selection. They should also be confident in their ability to address the common misconceptions that are introduced during this unit. The Understanding Evolution resource created by University of California-Berkeley and the University of California Museum of Paleontology is an excellent resource for both students and teachers to familiarize themselves with these concepts (7). The open source textbook *Biology 2e* by OpenStax has a good section on evolution as well (8).

SCIENTIFIC TEACHING THEMES

Active Learning

This lesson uses role play as the key active learning strategy. This engages students directly in the process of natural selection. The exercise ends with a minute paper in which students actively retrieve, explain and analyze the simulation. This could lead to a paired or class-wide discussion at the instructor's preference. Therefore, both large group and individual learning are incorporated to include the whole class in a variety of ways.

Assessment

Instructors may choose to collect the minute papers as informal, no-stakes assessments to double-check student understanding. A brief outline of what to look for in student answers is provided in Supporting File S3. Natural Selection Role Play – Answer Guide. A grading rubric is not provided as this is intended to be an ungraded informal assessment. The instructor may collect the papers to quickly assess student understanding. A summative assessment question on an exam may formally assess the students' ability to articulate the criteria for natural selection or address common misconceptions of evolution.

Inclusive Teaching

This activity engages the large majority of the class, if not the entire class, as the class itself becomes the natural population under selection. This builds community and engages all students, even those who normally don't volunteer, in a simple, low stakes activity. The minute paper reflection provides opportunity to every student to engage independently with the content. The structure, a mixture of large and individual work engaging the entire class is designed to include all of the students.

LESSON PLAN

Class Context

This short role play activity easily integrates into any lesson that introduces the basics of evolution, I have used this activity as part of a 50-minute class period that was the first lesson of a unit on evolution. Some class time before the activity (about 10 minutes) should be devoted to introducing the definition of evolution and the process of natural selection. I have provided the material I used to introduce these concepts, but the role play activity can be integrated into any classroom that has covered this material (Supporting File S1. Natural Selection Role Play – Intro Slides). This is discussed below. I have used this activity in both a non-majors' biology course and an introductory biology course with equal success.

Pre-Class Preparation

Before class, instructors should review the slides to be familiar with the activity and have a plan to introduce the required background information. They will need to plan the logistics that fit their classroom, including what trait they would like to use, how they plan to hand out trait cards, and how they will execute the role play. They will also need to print out or write trait cards in the appropriate number for their class size. I find it easiest to take index cards and label them with the traits (High, Medium, Low for this example). An excess of trait cards, greater than the number of students in the class, should be prepared to make sure there are enough for several rounds of selection and reproduction. In particular, a greater number of the “advantageous” trait will be needed as those traits increase in frequency during the course of the activity.

Introduce Natural Selection

Before the activity, it is important that the instructor introduce the definition of evolution and, in particular, the process of natural selection. It should be emphasized in the introductory material that evolution is the change in allele frequency in a population over time. This definition can be explicated to address some common misconceptions of evolution, as in the

provided slides (Supporting File S1. Natural Selection Role Play – Intro Slides). Further, the four mechanisms of evolution must be introduced (mutation, migration, genetic drift, and natural selection) to emphasize that natural selection is only one mechanism of evolution. Although the introductory material can be presented as desired by the instructor to match the context or style of the course, the instructor must introduce the four conditions necessary for natural selection to occur: 1) There must be variation for the trait in the population, 2) Individuals in a population must reproduce, 3) Variation must be heritable, 4) There must be differential fitness that is associated with one version of the trait (7). The introductory slides used in my classroom can be found in Supporting File S1. Natural Selection Role Play – Intro Slides.

Natural Selection Role Play

After covering the introduction material, it's time for the role play! Hand out shuffled cards with traits to approximately half of the class and ask them to stand. These cards will have specific traits. In my introductory plant biology class, I used trichome number (high, medium, low) in a population of plants. In my non-majors' class, I used speed (fast, medium, slow) in a population of rabbits. You can customize your population to meet whatever fits with your class or what you think will resonate with your students. I have provided the slides I use to guide the activity with trichome number, but that trait can easily be substituted for whatever fits the course content best (Supporting File S2. Natural Selection Role Play – RP Slides).

Handing out cards to only half of the class ensures there will be students available to become offspring. I hand out the traits in the following proportion: 40% advantageous trait (High number of trichomes/fast), 30% medium, and 30% disadvantageous trait (low trichome number/slow). After I hand out the trait cards, I ask the students to report what trait we are discussing and what is the variation observed. Then, I emphasize that our population has met the first criteria for natural selection 1) There must be variation in the population. A brief discussion of how this trait could be favorable could follow, depending on the class. In my introductory plant biology class, I like to use this time to have them recall the function of trichomes on leaves which we discussed in a previous lesson. I then prompt the students to recall the second criterion of natural selection; 2) The individuals in a population must reproduce. For this criterion, I tell the students that this is a reproducing population so this criterion is met.

I prompt students to recall the third criterion for natural selection: 3) Variation must be heritable. I inform them the trait is heritable and provide them the inheritance pattern of the trait. I emphasize that because this trait is heritable, it is mediated by a gene and therefore there are different alleles in the population. For sake of simplicity, I arbitrarily decided the more advantageous trait exhibits dominance using the guide on Slide 7 (Supporting File S2. Natural Selection Role Play – RP Slides). To emphasize the heritability of the trait, I have students find a partner and “reproduce”. They then recruit one of the students sitting down to be their offspring and determine the trait of that offspring by the inheritance pattern. I provide the new offspring with a card with the appropriate trait and ask them to stand. I then take a tally on the board of the numbers of individuals in each trait category and label this “Generation

1.” An outline of the table I create on the board can be found in Slide 6 (Supporting File S2. Natural Selection Role Play – RP Slides).

Then, I ask students to recall the final criterion for natural selection 4) There must be differential fitness associated with one version of the trait. This is a good time to emphasize the accurate definition of fitness (the ability of the organism to reproduce). For my plant example, the selection pressure is a caterpillar and for the rabbit example the selection pressure is a fox. I provide the following criteria to determine which individuals in the population survive: All “advantageous” individuals survive (high trichome number or fast), half of all the medium individuals survive, and one quarter of the “disadvantageous” individuals survive as seed on slide 8 (Supporting File S2. Natural Selection Role Play – RP Slides). You will need to determine how many students of each trait will “die” based on the starting number. I ask all the students who have a particular trait to raise their hands, and I select those who die while trying to disperse them evenly throughout the classroom. For example, if the medium group has 12 students, I select 6 students to “die”, take their trait card, and have them sit down. This is obviously a simplified version of what would happen in nature, which I make sure to explain to my students.

I then have students reproduce again, emphasizing that it was only those who survived the selection pressure who were able to reproduce, following the same guidelines as before and record the population numbers as “Generation 2” on the table. Then, the selection pressure comes again and I repeat the cycle at least twice, for three total phases of selection, or until the change in trait frequency is obvious. Students who “died” in previous generations can become offspring of subsequent generations. This is a good point to reiterate the true definition of fitness - and that the remaining organisms have higher fitness because they get the chance to reproduce and pass on their traits to the next generation. I continue the cycle of selection and reproduction, taking tallies of the traits after each generation. Usually after three generations, a pretty drastic change in allele frequency is observed. At this point, I summarize that our population has had a change in allele frequency and is therefore under selection and evolving. I then have students sit down to begin the minute paper reflection.

At the end of the activity, I guide students in an individual reflection of what we just observed using a minute paper. Possible minute paper prompts are included on slide 11 (Supporting File S2. Natural Selection Role Play – RP Slides). During this reflection process, it is important to reemphasize some of the common misconceptions as well as the definition of evolution as “a change in allele frequency over time.” As I have integrated this lesson into a longer session on the mechanisms of evolution, I come back to this example when discussing how mutation, migration, and genetic drift impact our established population. For example, I emphasize that mutation led to genetic variation in the trait, migration could bring in more individuals of a particular trait, and genetic drift may change the allele frequency randomly. This further underscores that natural selection is only one mechanism of evolution.

TEACHING DISCUSSION

Reflection

I have successfully used this activity in both non-majors and introductory biology courses. The main benefit of this activity, which has been reported to me by students, is that it provides a concrete example of natural selection that they can visualize and refer back to when studying. In addition, it builds community in the classroom because it gets everyone involved in the drama of reproduction and survival. Beyond that, I have found that most students are able to accurately describe natural selection, the criteria for natural selection, and why natural selection is not the same as evolution on exams and quizzes. In addition, it provides a common ground example for further discussions. I have frequently found myself saying “Remember our population? Well what if...” Students more easily engage in this conversation rather than if I bring up a traditional example from the published literature. Because the students “lived through” selection, they have more tangible understanding of the process. It is important to include the minute paper prompt so that all students can fully engage in the process. Large class role play is fun and provides an example, but the minute paper is when students put in their own words what they observed to help solidify the ideas in their own mind.

Options for Modification

The role play can be modified to smoothly integrate into course content. I chose trichome number in my majors’ class because we had discussed trichomes previously and it provided an opportunity to revisit that content. For non-majors I used a population of rabbits and speed because this was something I thought they could easily visualize. Instructors may do the same in their classrooms, choosing traits that had been discussed previously or traits that align with course content and themes or whatever the instructor is excited about! This activity is flexible and adaptable. This activity could also be adapted to demonstrate canonical examples of evolution, such as the coloration of moths during the industrial revolution (8, Section 19.3). This activity is best designed for smaller classes, adapting for a larger class may be more challenging but could possibly be done with the assistance of teaching assistants to disseminate cards and count students. While this activity is difficult to adapt to online learning, it is very amenable to physically distanced in-person spaces in the era of pandemic learning.

Lesson Integration

This activity easily integrates into any class session on evolution, does not take a substantial amount of class or preparation time, and is fairly simple for both instructor and students to follow. Because of this, it is an excellent starting off point for instructors unfamiliar with active learning strategies or busy instructors who are looking for something for their introductory biology classroom. I have found this activity best used in the first introduction to evolution in a non-majors or introductory biology, when students are just beginning to understand evolution or are refreshing what they have previously learned.

In general, this short role play activity addresses misconceptions in evolution, teaches the process of natural selection, and gives students a concrete example to support

their growing understanding of evolution. It allows for group interaction and comradery while also providing space for personal recollection and synthesis. As this activity is simple, flexible, and low-commitment it can be used by instructors with any degree of active learning confidence and in any introductory biology classroom.

SUPPORTING MATERIALS

- Supporting File S1. Natural Selection Role Play – Intro Slides
- Supporting File S2. Natural Selection Role Play – RP Slides
- Supporting File S3. Natural Selection Role Play – Answer Guide

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Table 1. Lesson Plan Timeline.

Activity	Description	Estimated Time	Notes
Preparation for Class			
Prepare Trait Cards	Print and cut out cards with designated traits in an appropriate number for your class OR write them on notecards.	10 minutes	<ul style="list-style-type: none"> Make sure there is enough of each trait for the initial population and then extras of each trait for subsequent rounds of reproduction. You'll especially need more of the most advantageous trait. Plan to have close to your whole class with the advantageous trait by the end. If I run out of trait cards for some reason, I find students are able to remember their trait if needed.
Review Material and Plan Logistics	Decide your trait, plan how you easily disseminate cards and how you will monitor the population changes.	Variable	<ul style="list-style-type: none"> Think about how you can customize this activity for your classroom, particularly what trait you want to use. You can use anything as long as it is biologically sound. I have always used three alleles to show increased variation. Make sure you are comfortable with the slides and have your logistics planned so the activity will run smoothly – a few minutes of visualizing your plan will go a long way!
Class Session			
Introduce Evolution	Introduce the definition of evolution, mechanisms of evolution, and process of natural selection.	~10 minutes	<ul style="list-style-type: none"> The slides I use to introduce the activity are provided in Supporting File S1. Natural Selection Role Play – Intro Slides, but feel free to complete this section as you see fit for your classroom.
Natural Selection Role Play	Move through the steps of the Role Play.	~10 minutes	<ul style="list-style-type: none"> Using the slides provided in Supporting File S2. Natural Selection Role Play – RP Slides, go through the activity. Collect data on board using provided table template and move through as many rounds of the role play as you desire, but at least until the change in allele frequency is evident (at least three rounds total).
Minute Paper	Have students complete minute paper prompt.	~2-10 minutes	<ul style="list-style-type: none"> The timing on this section will depend on how long you want the students to write and whether or not you would like to discuss the prompt with the class. Give the students at least 2 minutes to write their answers in their notebook or on a separate sheet of paper. These papers may be collected for an informal assessment of their understanding.