**Supplemental Materials**

**Interview Protocol**

Thank you for agreeing to be interviewed. My name is \_\_\_\_\_\_. In this interview, we are going to begin by asking you about your antibiotic resistance models and then we’ll ask you about models in general.

PART I: Antibiotic Resistance and Natural Selection

1. Talk us through your third model that you drew on the last page of the antibiotic resistance packet.

Prompt for *how* and *why.*

1. Look back at your first models and talk about how your ideas have changed since the beginning of the unit. What experiences in class caused your ideas to change?
2. Now let’s look at your second model and explain your drawings.
3. Critique the antibiotic resistance lab –
   1. what did you learn from the lab?
4. Recall when you worked in small groups and whiteboarded a generalized model of natural selection. What did you draw upon to draw that model?
5. Let’s return to the final model. How well does your final model reflect your understanding of antibiotic resistance?
6. How close does your model match reality (the real world)?

PART II: Models in General

1. Both times we’ve talked with you in these interviews, we have looked at models you’ve drawn.
   1. How do you define models? What are they?
   2. What did you learn about models in the climate change unit?
   3. What did you learn about models in the antibiotic resistance unit?
   4. How has your thinking about models changed, if at all, after these two units?
2. Talk to me about the value of drawing models . . . what do you gain from drawing them, if anything?
   1. For you as a student?
   2. For scientists?
3. In the antibiotic resistance unit, we had you compare your first and final models, and you did a peer review of your classmate’s models, *what* criteria do you use to critique a model?

In other words, what makes a good model?

Thank you for sharing your thoughts with me today.

**Qualitative Analysis Code Key**

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| --- | --- | --- |
| **a Priori Code** | **Description** | **Example** |
| Mutation | Explanation includes mutation | “I put x’s through them to indicate that this is the random mutation that was happening in the strep bacteria…” |
| Favourable Trait | Explanation includes favourable trait (resistance or general) | “…a certain group is favored because they have some sort of advantageous trait…” |
| Initial Variation | Explanation includes initial variation in the population | “At the very beginning, we just have a general environment with two variations…” |
| Selective Pressure | Explanation includes selective pressure (antibiotics or general) | “…once the amoxicillin was taken by the person…” |
| Differential Survival | Explanation includes differential survival (individuals with the favourable trait survive, while those without die) | “…there’s an environmental change that kills off all of the bacteria that aren’t resistant so the overall population drops a lot, which is why you feel better at first. But the resistant ones survive…” |
| Reproduction | Explanation includes reproduction | “But then, bacteria reproduced exponentially, and it’s really fast also.” |
| Population Shift | Explanation includes a shift in the population in terms of the favourable trait. | “…then you see a greater prevalence of the squares in the last, in the final population because they were the ones that benefitted from the environmental change and were able to reproduce more.” |
| Misconception/ Misunderstanding | Explanation includes a natural selection misconception, a partial understanding, or a misunderstanding. | “And so then a few of them kind of hide out somewhere until, and then they know, the ones that hid out, are like “Oh the antibiotics are going to rain down on us if, in this next situation” and then they have umbrellas so then they prevented that from happening.” |

**Expanded Wilcoxon Signed-Rank Test Results**

**Initial**

**Variation**

**Reproduction**

**Favourable**

**Trait**

**Differential**

**Survival**

**Population**

**Shift**

**Mutation**

**Selection**

**Pressure**

*Figure 1.* The bars indicate groupings in which factors are not significantly different from each other. For examples, initial variation, mutation, and reproduction are not significantly different while initial variation and selection pressure are significantly different.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Table 1. Factors Wilcoxon p Values. (Adjusted α = 0.0024)** | | | | | | | |
|  | Mutation | Initial Variation | Favourable Trait | Selection Pressure | Differential Survival | Reproduction | Population Shift |
| Mutation |  | 0.02678 | 0.07891 | **0.000\*** | 0.03109 | 0.3586 | 0.03109 |
| Initial Variation | 0.02678 |  | **0.000\*** | **0.000\*** | **0.000\*** | 0.004491 | **0.000\*** |
| Favourable Trait | 0.07891 | **0.000\*** |  | 0.0726 | 0.7897 | 0.1647 | 0.8016 |
| Selection Pressure | **0.000\*** | **0.000\*** | 0.0726 |  | 0.04108 | 0.002602 | 0.04108 |
| Differential Survival | 0.03109 | **0.000\*** | 0.7897 | 0.04108 |  | 0.1779 | 1 |
| Reproduction | 0.3586 | 0.004491 | 0.1647 | 0.002602 | 0.1779 |  | 0.1096 |
| Population Shift | 0.03109 | **0.000\*** | 0.8016 | 0.04108 | 1 | 0.1096 |  |

**Mutation Causes Favourable Trait**

**Mutation Causes Initial Variation**

**Favourable Trait and Selection Pressure Cause Differential Survival**

**Reproduction and Differential Survival Cause Population Shift**

*Figure 2.* The bars indicate groupings in which connections are not significantly different from each other. For examples, *mutation causes favourable trait* and *reproduction and differential survival cause population shift* are not significantly different while *mutation causes initial variation* is significantly different from all other connections.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Table 2. Connections Wilcoxon p Values. (Adjusted α = 0.0083)** | | | | |
|  | Mutation Causes Favourable Trait | Mutation Causes Initial Variation | Favourable Trait and Selection Pressure Cause Differential Survival | Reproduction and Differential Survival Cause Population Shift |
| Mutation Causes Favourable Trait |  | **0.000\*** | **0.0078\*** | 0.2841 |
| Mutation Causes Initial Variation | **0.000\*** |  | **0.000\*** | **0.000\*** |
| Favourable Trait and Selection Pressure Cause Differential Survival | **0.0078\*** | **0.000\*** |  | 0.05719 |
| Reproduction and Differential Survival Cause Population Shift | 0.2841 | **0.000\*** | 0.05719 |  |