## Name: Date: Period:

## “The Beetle Project: Investigating insects in a warming world”

## Reading Guide for “Natural selection from the gene up: The work of Elizabeth Dahlhoff and Nathan Rank”

**Directions:**

Access the Research Profile/case study at <https://evolution.berkeley.edu/evolibrary/article/0_0_0/dahlhoff_rank_01>. As you read this research profile, answer the questions below (questions are correlated with their related sections and pages). Use complete sentences that restate the question. Use the information in the reading to construct your own explanations and descriptions.

**Natural selection from the gene up: The work of Elizabeth Dahlhoff and Nathan Rank (page 1)**

1. Explain what an evolutionary adaptation is. Support your explanation by referencing one of the two evolutionary adaptations referred to in the first paragraph of the reading.
2. If the evidence for natural selection is overwhelming, why do you think it is so difficult to scientifically substantiate its occurrence in nature? Use your own words.
3. Why might a phenomenon like climate change provide Elizabeth Dahlhoff and Nathan Rank with an opportunity to study natural selection occurring in the willow leaf beetle?

**Meet the willow leaf beetle (page 2)**

1. Create a life cycle diagram for the willow leaf beetle. Include labels for each life cycle stage (e.g. egg, larva, pupa, adult) and the time of year that each stage occurs.
2. What characteristics of the willow leaf beetle make them a good model for studying the effects of climate change? Explain using your own words.
3. Propose and explain at least three alternative mechanisms that could change the relative frequencies of the *PGI-1* and *PGI-4* alleles in separate populations of the willow leaf beetle in the Sierra Nevada.
4. Considering your answer to question 6, why was it important for Nathan to study the history of the willow leaf populations that he was monitoring. In general, how does protein electrophoresis work and what information about proteins can it provide? (Look this up if necessary, but make sure your explanation is in your own words.)

**An unlikely scientific pair (page 3)**

1. Do you think that Nathan and Elizabeth are an unlikely scientific pair? Discuss.

**The task ahead of them (page 4)**

1. How did Team Beetle begin its investigation? What did the team discover?

1. What hypothesis did Team Beetle propose to explain the correlation of temperature with the relative frequency of *PGI-1* and *PGI-4*?

1. What specific evidence was necessary to support Team Beetle’s hypothesis? (See 12 a. for an example.)
   1. Genotype difference: *Evidence that the PGI gene was polymorphic (had different versions/alleles) in the leaf beetle populations.*
   2. Phenotype difference (recall that phenotypes can be expressed at different scales and in different ways).
   3. Performance difference:
   4. Fitness difference:
   5. Gene frequency change:

**Enzymes in the lab (page 5)**

1. Briefly describe how Elizabeth demonstrated a phenotypic difference between PGI-1 and PGI-4 in the lab. What were her findings?
2. Why might some proteins unfold more easily than others?
3. Why was it important to follow up the heat treatment experiment with field research?

**Investigating the physiological differences (page 6)**

1. What is the function of an HSP or “stress” protein?
2. Why does the HSP-associated “rescue” of unfolded proteins come with a trade-off?



1. Evaluate the graph. Which genotype seems to be the most “stressed out” as temperature begins to increase? Use data points from the graph to support your answer.
2. How did Team Beetle demonstrate that HSP production in wild populations of beetles works the same as in beetles evaluated in the lab?

**Observing change over time (page 7)**

1. If Team Beetle’s hypothesis is correct, what would you expect to happen to the frequency of a cold-adapted *PGI* allele in a cooling climate over time? Why?
2. Team Beetle’s findings are graphed below. Does the data support the hypothesis? Why or why not?



## The amazing beetle race (page 8)

## What was the purpose of racing the willow leaf beetles? How is the speed at which a beetle can move correlated with fitness?

## Discuss the expected and the unexpected findings of the beetle race experiment.

## Expected:

## Unexpected:

## How did the unexpected results change the way the team thought about the PGI alleles and temperature?

## Did the Nathan’s and Elizabeth’s hypothesis change as a result of these findings? If so, how?

## Beetle babies (page 9)

## Why is evolutionary fitness an essential component of the mechanism of evolution by natural selection?

## How did the team measure the fitness of each PGI genotype?

## What new information was generated by the egg-laying experiment? Did it support the hypothesis? Discuss the race car/jeep idea and the connection with HSP.

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## The last first step (page 10)

## What molecular biology technique was used to ascertain the exact base-pair sequence of each *PGI* allele, and thus to provide the last piece of evidence for this research piece? Why didn’t Nathan perform this first step in the research process back when he started studying the willow leaf beetle?

## What did the sequencing results show? How do the *PGI-1* and *PGI-4* differ in their nucleotide sequences? How does this translate into a difference in the PGI-1 and PGI-4 proteins?

## Beetles in a warming world (page 11)

## What do the Beetle Team and Nathan and Elizabeth do now that they have generated the necessary evidence to support their hypothesis?