Name_____

The Case of the Three-Spine Stickleback

A Model of Macroevolution

RESPONSES TO QUESTIONS

PAGE 2: Are Pelvic Spines and Body Armor Inherited?

As we stated above, in order for particular traits to be affected by natural selection, they must vary within populations and they must be inherited. So what about pelvic spines and body armor? We know that these traits vary between *marine* and some *freshwater* populations, but are these traits inherited? Perhaps simply living in certain kinds of freshwater causes the loss of these traits in a reversible manner. **How could we test this? What could you do to that might tell you if pelvic spines and/or body armor are inherited? Discuss your ideas with your classmates and record your best ideas below.**

PAGE 3:

Based upon what you have learned about the rules of inheritance, **what can you conclude about the alleles that control pelvic spines and body armor in threespine sticklebacks? Write your answer in the space below. Using letters to represent the alleles (i.e., different forms) of the genes that control pelvic spines and body armor, diagram what happened in this breeding test.**

Based upon your answer to the question on the previous page, perhaps you can make another prediction. **What do you think would happen if the fish from the first (F_1) generation were artificially bred with each other? Write down your prediction here.**

PAGE 4:'

Based upon these results, **what would you conclude about the pattern of inheritance of these two traits (i.e., pelvic spines and body armor) in threespine sticklebacks? Write your answer in the space below. Again, using letters to represent different alleles of the genes controlling pelvic spines and body armor, diagram what happened when members of the F_1 generation were bred with each other.**

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Here is what they did. Recall that the DNA code of genes is translated into mRNA in places where those genes are activated. These days, scientists are able to detect the presence of particular mRNA by binding these mRNAs to a blue dye that will be visible in the tissues only where the specific mRNA molecules are being made. The scientists did an experiment where the pattern of *Pitx1* mRNA production was compared between *marine* and *freshwater* stickleback embryos. **Discuss this experiment with your classmates and write down what you think probably happened. Do this below**.

PAGE 7:

So what can you infer about where the coding region of the *Pitx1* gene is being transcribed into mRNA in these embryos? Write your answer below and explain why you said what you did. Did your prediction match the results of the experiment. Explain.

PAGE 8:

The diagram in Figure 7 shows the working hypothesis that the scientists investigating *Pitx1* expression in sticklebacks have proposed to explain their results. Although they have not yet identified the specific mutation that causes the transcription of *Pitx1* mRNA to be "turned off" in the pelvis, it seems very likely that it is located in the piece of "regulatory" DNA segment that normally activates *Pitx1* transcription in the pelvis (i.e., the green circle in Figure 7).. **The "regulatory" pieces that control transcription of the gene in the olfactory region (i.e., "nose") and jaw are unaffected. How do we know this?**

Most of you would agree that if a human were to be born without a pelvis, this would represent a drastic (and detrimental) change. Natural selection would certainly not preserve this variation (**why not?**). Yet, in threespine sticklebacks, selection has clearly favored the elimination of the pelvis in a very "short" time (i.e., no more than 12,000 years). Why? Although we don't know for sure, apparently fish that normally prey on sticklebacks are absent from some freshwater lakes; and, conversely, in those lakes, large predatory insect larvae that can grab the spines of sticklebacks (and eat them) are often present. **How might such observations explain the absence of pelvic spines in terms of Darwin's theory of natural selection? Write your explanation below and continue on the back of this page if necessary.**

PAGE 8 (Continued):

Another feature of evolutionary theory is that variation in populations ultimately arises from gene mutation followed by selection for a particular mutation. In this example, scientists think they have identified both the type of mutation involved and its approximate location in the DNA. In this case, a presumably small genetic change (mutation in a piece of regulatory DNA) results in a large-scale morphological change (the loss of the pelvis). **So is this microevolution or macroevolution? Write a short paragraph giving your answer and justifying your position.**

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As you can see from looking carefully at Figure 8, mice whose *Pitx1* gene has been "knocked out" not only fail to survive, but show multiple defects in the head, jaw, pelvis, and hind limbs. Yet, threespine sticklebacks that have completely lost the pelvis show *no* defects. **How can you explain this difference? How would the diagram of the *Pitx1* gene that is shown in Figure 7 for marine and freshwater sticklebacks look if it was showing the gene in a *Pitx1* "knockout" mouse? Discuss this with your classmates and summarize your ideas in the space below.** Your instructor will discuss this with you. *Understanding the difference between these two cases is critical to understanding how evolution does (and doesn't) work.*

PAGE 10:

Now, based upon what you have learned, you should be able to make a reasonable (and perhaps testable) hypothesis about the genetic basis of limb loss and pelvic reduction in manatees and how this condition might have evolved. Again, **using the type of diagram shown in Figure 7, what would you hypothesize that appearance of the *Pitx1* gene complex would be in manatees? Show the diagram below and explain your reasoning.**

PAGE 11:

In at least some species that have lost their hind limbs, rare individuals occur in whom the lost structure re-appears. These "re-appearances" of ancestral structures are called *atavisms*. Figure 10 shows an atavistic hind limb in a dolphin that was caught by Japanese researchers in 2006. Given what you have learned about the *Pitx1* gene, **what might be the genetic basis of this atavism? Use another diagram of the *Pitx1* gene complex to illustrate your hypothesis.**.