HOW NOVEL ICEFISH GENES CAN IMPROVE HUMAN HEALTH

INTRODUCTION

Icefish are among the few fish families that thrive in the oxygen-rich cold waters surrounding Antarctica. They have evolved a set of unique adaptations that enable them to survive in an environment that would be deadly to other fish. Several of these adaptations are associated with major health problems in humans. Can icefish help us understand human disease? Scientists certainly think so. The novel genes responsible for the icefish's unique set of traits might lead to new treatments for common diseases such as anemia and osteoporosis.

PROCEDURE

1. As you watch the short film *The Making of the Fittest: The Birth and Death of Genes*, list the icefish adaptations below.

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2. After watching the film, read the paragraphs below and answer Questions 1–3.

People are diagnosed as being anemic if their blood lacks an adequate number of healthy red blood cells or if their red blood cells are deficient in hemoglobin. Both conditions result in an inadequate amount of oxygen reaching different tissues in the body. In humans, red blood cells are produced in the bone marrow. Once they enter the bloodstream, healthy red blood cells circulate between 90 and 120 days before the body breaks them down and recycles them.

There are more than 400 different types of anemia. We can divide them into three basic groups, depending on their cause.

Anemias can be caused by

- defective or decreased red blood cell production,
- defective hemoglobin,
- red blood cell destruction, or
- blood loss.

Studying the icefish could provide information that would help develop treatments and possible cures for the first two types of human anemias. For example, scientists have compared the genome of icefish, which lack red blood cells, to those of their close relatives that have red blood cells. The comparison led scientists to a novel gene, named *bloodthirsty* (*bty*), that is expressed in icefish relatives but not in icefish. Scientists are investigating the role of the *bty* gene in red blood cell formation and destruction.

QUESTIONS

1. From the list of adaptations you recorded during the film in Step 1, (a) list the icefish traits that would be of direct interest to researchers investigating anemia in humans and (b) explain how each trait is related to anemia.

a. Traits

b. Explanations

2. Below is a chart of icefish adaptations that the film does *not* mention. Using your knowledge of anatomy and physiology, place a check mark on the line in front of the three adaptations that *most* directly play a role in ensuring that icefish tissues receive an adequate amount of oxygen.

Icefish Adaptations Not Mentioned in the Film

___ Enzyme molecules that work at low temperatures	___ Low blood pressure
___ Large heart	___ Large, bulging eyes with lots of rods
___ Abundance of lipids distributed throughout the body	___ Wide blood vessels
___ Large volume of blood	___ No swim bladder

3. Write a paragraph that explains how the adaptations you selected enable icefish tissues to receive an adequate amount of oxygen.

Read the paragraphs below and answer Question 4.

Another adaptation that has piqued the interest of researchers is the light, thin skeleton of icefish. Essentially, icefish have reduced their bone density. Just how did icefish come to decrease the mineralization of their bones and replace bone with connective tissue?

About 34 million years ago, icefish lived on the ocean floor. They were so well adapted to life on the ocean bottom that they lost the swim bladder. In other fish, the swim bladder regulates buoyancy, making it possible for them to move up and down in the water column. When the temperature of the ocean surrounding Antarctica began to drop, other fish species either died out or migrated to warmer regions. This left the bottom-dwelling icefish with new niches to exploit. The problem was, without swim bladders, they could not get to food that was available higher up in the water column. Over a period of approximately 4 million years, icefish shed bone density, thus increasing their buoyancy. This trait mimics the human condition osteopenia, which is a lower-than-normal bone mineral density. In the United States, osteopenia affects 34 million women and 12 million men. Osteopenia often leads to osteoporosis, which is a disease characterized by bone deterioration and increased susceptibility to bone breaks and fractures.

Researchers have discovered that the demineralization of icefish skeletons occurs through a change in the timing of gene expression. Genes that regulate bone growth switch on for only a brief time during icefish development, whereas genes that build cartilage are active for a much longer time.

4. Explain how understanding the evolution of the demineralization of the icefish skeleton might help scientists find an effective treatment or cure for osteoporosis.

EXTENSION ACTIVITY

Complete the essay framework below. It provides a way to organize information for an essay supporting the use of icefish as model organisms in the study of human disease. We have provided you with the essay title and the proposal your essay would support. You will need to review the short film and investigate other sources to find some of the information you need to complete the essay framework.

Essay Framework

Essay Component	Description
Title	*"Icefish as Model Organisms"*
Proposal	*Antarctic icefish have evolved a unique set of adaptations, several associated with serious health problems in humans. A study of the icefish genome would provide information that scientists could use to understand and treat human disease.*
Definition of the model organism	
Four examples of icefish adaptations and their associated human diseases	
Two examples of how the birth and death of genes are associated with the evolution of these adaptations	
What scientists say about using the icefish as a model organism (provide three examples along with appropriate references)	
Conclusion	

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