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Candidate Index Number: _____

Biology, Case 2

Topic: Why Sex is Good

Marks: 60

Credits

*Our appreciation to **Clyde Freeman Herreid,** Department of Biological Sciences University at Bufalo, State University of New York, who authored this case study. For purposes of improved readability and summary writing, some modifications **may** have been made to the original text.*

Abstract

This interrupted case is based on a 2005 article in *Nature* written by three scientists from the Imperial College London that deals with the issue of sexual vs. asexual reproduction and their relative merits - a question that has bedeviled biologists for over 100 years. The article serves as the final stage of this case focusing on why sex is good (at least in some circumstances).

Objectives

- To emphasize the methods of designing and collecting evidence to test a hypothesis.
- To examine a major hypothesis in evolutionary theory—the evolution of sex.

The Case – Part 1

Why do so many organisms go through sexual reproduction? It seems like every organism we think about does it: clams, jellyfish, trees, and elephants. And while we're thinking about it: why only two sexes? It doesn't have to be that way. Some fungi have dozens of sexes, enough to keep a romance novelist and a scriptwriter of soap operas ecstatic for years.

Sex really isn't necessary for reproduction. Bacteria and many one-celled organisms like amoebae reproduce quite nicely by simply dividing in half (binary fission). They produce identical copies of themselves, quite an efficient way of sending one's genes on to the next generation. They do it alone. For them, it doesn't take two to tango. Complex organisms can do it too. Some lizard species have only one sex - females. They reproduce parthenogenetically - that is, females produce eggs that spontaneously start development without sperm being involved at all. They are completely asexual.

Some species have it both ways: they reproduce both sexually and asexually. Queen bees when they produce females (workers), release sperm out of a storage sac and fertilize the egg in the normal way, but when they want to produce males (drones) they hold the sperm back and the eggs develop by parthenogenesis.

Water flea (Daphnia) populations seem to switch from asexual to sexual depending on environmental conditions. And some species of fish actually switch from being one sex to the other depending on which gender is in short supply. Science fiction writers should love these gender benders.

So, this brings us to a fundamental question that biologists have not solved: If organisms can survive well without sex- in fact, may do better without it - why has sexual reproduction evolved?

Questions

1. Propose three hypotheses to explain why sexual reproduction has evolved. (At least 20 have been suggested!)
2. Can you propose any way to test your favorite hypothesis?

The Case – Part 2 – Is it always good?

> *In a world without sex there would be no males and females. No flowers, no insects specialized in pollinating them, no extravagant colour and form like the peacock's tail; and much animal behaviour would not exist. —Rolf Hoekstra*

All of that is true, but so what? Who needs this stuff that Hoekstra is talking about for survival?

The great German biologist August Weismann proposed an answer to the question of "Why sex?" He asserted that sex increases genetic variation. When two different individuals mate by joining their gametes together, they produce a brand new genetic mixture and this promotes evolutionary adaptation.

This idea held sway for a hundred years until a couple of authors, George Williams and Maynard Smith, said, "Hold on. There are a couple of problems with this scenario." Sex is not always good.

1. Mixing of the genes tends to break up favorable combinations. Why break up a good thing?
2. Asexual reproduction is twice as efficient as sexual reproduction at sending one's genes into the next generation. Every time a sexual mother produces a child, that child only has one-half of the mother's genes; the other half is from dad. An asexual mother reproducing parthenogenetically would give her child the complete set. In fact, it is better to have every individual in a population capable of reproduction (i.e., be a female) than to have individuals who are not (i.e., be a male). Such populations should rapidly out-reproduce a sexual population. This has been called the "twofold cost of sex."

On both of the above counts, it seems clearly disadvantageous for individuals to reproduce sexually! Yet sex has evolved and seems here to stay. Many scientists have tried to puzzle their way out of this dilemma by testing some of the assumptions inherent in the argument.

As the four students were doing the experiment, they noticed that the two ice cubes not only melted at different rates, they also melted in different ways. The one in fresh water was becoming smaller and smaller all around, but the one in salt water seemed to be staying the same size when looked at from above. The one in salt water was also melting more slowly. It looked like it was not melting from the sides. They wondered whether it was melting from the top down or from the bottom up?

Question

1. Can you design a way to test the hypothesis that asexual reproduction leads to a higher evolutionary fitness (i.e., leads to more progeny) than sexual reproduction?

The Case – Part 3 – Sex and Stress

There is a snail that lives in New Zealand lakes that has both asexual and sexual individuals. Curtis Lively (currently at Indiana University) and his colleagues decided that the snails could be used to test the hypothesis that a changing or stressful environment would favor sexual reproduction - the logic being that if the environment changes, then variation (sexual reproduction) is a good thing; some of your of spring might have the right genetic constitution to survive.

Here's the situation the biologists found. The snails live in freshwater habitats and there are over a dozen worm parasites that attack them. The scientists reasoned that there might be a difference in the fitness of the asexual and sexual individuals in ponds where there were different degrees of parasitism.

This is what they found: in ponds where there was a high degree of parasitism there was a much higher percentage (2.5 times more) of sexually reproducing individuals.

Questions

1. Before carrying out the experiment, why did the scientists expect there would be a difference in fitness between sexual and asexual snails in ponds with diferent degrees of parasitism?
2. Is the data they obtained consistent with Weismann's hypothesis? Explain your thinking.