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PIG CLONING SHOWS WHY SCHOOLS MUST TEACH EVOLUTION

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TERMINATED GENE RESEARCH SEEMS LIKELY TO RISE AGAIN

Poor Monsanto. It probably did the right thing but for the wrong reason. The bio-technology giant announced last year that it would cease developing seeds that grow into infertile plants. Crops with such "Terminator" genes would ensure Monsanto a return on its costs of developing genetically modified plants. Farmers would buy high-tech seeds but go back to Monsanto for each planting. Your plants yield more, but they're sterile; your seed costs rise, but your profits rise more.

But that math might not work if Terminator genes ride pollen grains to nearby, related "weeds." And in impoverished countries, farmers cannot afford even low-tech seeds.

The New York Times has called the development of Terminator technology a "public-relations disaster"

for Monsanto. It is even more a scientific-literacy disaster.

Our first ancestor who had more chickens than needed for eggs and ate the poorer layers invented genetic engineering through artificial selection. Natural selection, a driving force of evolution, acted on neighbors who couldn't count eggs.

Terminator technology is more sophisticated than Farmer Thag's selective breeding. But even new gene-splicing technologies have counterparts in the natural world. We now know that genes "jump" among species on their own.

Between natural and artificial selection, all food is engineered genetically. Banning genetically altered food mandates famine. The difference between Monsanto's genetic engineering and Farmer Thag's is more apparent than real.

Monsanto folded for the wrong reason. The Terminator gene deserved a fair hearing but didn't get it. People didn't understand the underlying biology. In school, they learned cell division but not natural and artificial selection. They memorized terms but never mastered the art of considering alternative hypotheses.

While stopping development of Terminator technology, Monsanto's chairman called for an "open, independent airing of all the issues raised by the use of gene-protection systems." He wants public consideration of alternative hypotheses. Can that occur? It's not likely.

This technology is not going away. Last month, the *Times* reported that the Scotts Co. in Marysville is developing genetically modified lawn plants. How will genes spliced into these plants not escape into wild plants? "The company says it may adopt a Monsanto technology called Terminator...."

Scientists at both companies assure me, "We're not working on Terminator technology" (Scotts) and, "There is no Monsanto 'Terminator' gene." Nonetheless, the Reuters agency reported the U. S. Department of Agriculture held public meetings two weeks ago to "consider the social and economic impact of the Terminator gene developed by department scientists" and a private company. This technology is anything but terminated, and the public is going to have to understand it and the underlying biology before these issues are resolved wisely.

We need to help Third World farmers. Genetically engineered crops developed by Monsanto and its competitors are part of the solution. So is an educated public.

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PIG CLONING SHOWS WHY SCHOOLS MUST TEACH EVOLUTION

"Someday, they're even going to clone pigs as human organ donors!" The image was Orwellian, but I needed a hook to tell my students why they had to understand molecular genetics and not just memorize such terms as *meiosis* and *mitosis*.

I was conducting a final exam review session last month for the 650 students in my introductory-biology

course at Ohio State. The hook worked; we had a productive session on genetics, evolution and the implications of each for society.

Two days later, on the morning of the exam, my students and I awoke to a front page headline: "'Dolly' creator makes first piglet clones." The latest achievement by the cloner of the Scottish sheep "could be a profoundly important advance toward the goal of modifying animal organs for transplant to humans," the article said.

Biology is moving faster than our public policies can evolve, and much faster than we can educate people to understand this science and respond to its brave new opportunities and dangers.

Xenotransplantation is the process of transplanting organs from other animals into humans. It is a dauntingly complex task and will likely entail preparing genetically acceptable "donors" through cloning or similar procedures. Indeed, this news of pig cloning is just a first step.

Pigs are similar enough to us in size, physiology and genes to serve as organ donors. Further, we already know how to raise them because many of us eat them.

Other potential donors, such as fellow primates, are even closer to us, but that similarity raises problems, as noted in *The Dispatch*: "The risk of passing diseases from pigs to people is less than the danger from primates such as baboons."

But if pigs are close enough to us to be good candidates as organ donors, why aren't fellow primates even better? Wasn't that the heart of a baboon that was transplanted into a little boy? What are these diseases in pigs (and baboons)?

The science behind these questions is easy to understand, but we biology teachers are intimidated from explaining it to our students. We are leaving them (and their parents, who pay our salaries) without the knowledge they need to participate in the development of public policy.

To understand the opportunities and dangers of xenotransplantation, one must understand evolution and how it works on populations, including those of pigs and humans. For some students (and their parents), talking about the forces of evolution is about as appealing as trying a baboon burger with bacon and cheese.

Natural selection is one of those forces of evolution that is controversial when it comes to teaching biology in schools and even colleges. But it explains the risks associated with transplanting organs from other animals to humans and why those risks are lower (but still real) if the donor is a pig and not a baboon. All alternative "theories" of natural selection are mute on the subject.

Evolutionary biologists have come to refer to the interactions between animals (pigs) and their pathogens (viruses) as an "arms race." A really aggressive virus and weak host pig result in no more pig and no more virus. Biologist Paul Ewald has pointed out that this can lead to several outcomes. One is a spectacularly aggressive virus (or other pathogen) that jumps from host to host before each host dies.

Through natural selection, however, host and pathogen populations can sometimes co-exist. The really deadly pathogens and weak hosts die (together); the weaker pathogens and stronger hosts co-exist for ever-longer periods. Eventually, this natural process of selection for less-deadly viruses and more-resistant hosts results in a truce: The host lives, the pathogen lives, and every time the host reproduces, so does the pathogen.

Technicians sequencing the human genome and those of other organisms are finding a vast amount of DNA they call "junk." It doesn't seem to code for anything other than itself.

I suspect that much of this "junk" is the product of truces that natural selection negotiated between our ancestors and their pathogens. We're sequencing the results of "peace treaties" we don't understand. And when we transplant "donor" organs containing the DNA text of such treaties into hosts that didn't participate in the armistice, we may unwittingly violate it. After all, upon successful transplantation of a pig kidney into a human, the human can survive and maybe reproduce; the virus can survive but not reproduce with the host if it just stays in the kidney. The treaty and truce are abrogated; the war is rejoined.

Pigs make good candidates for xenotransplantation donors because the genetic treaties they negotiated, and the viruses involved, are so old and different from us and our viruses that the pacts likely no longer apply. Baboon genetic treaties and the viruses that negotiated them are closer to us, however.

The AIDS epidemic is an example of what happens when a host-virus treaty is transferred between one host and another; the hosts were closely related primates, and the transfer likely occurred through predation. The treaty apparently was violated, with tragic results. Are pigs too close to serve as our donors?

Congress has considered many bills regulating human cloning. Regulations on xenotransplantation must follow. Hundreds of thousands of people stand to benefit from the technique. Similar numbers could suffer if transplanted viruses decide their 60 million-year-old treaty is broken, and they can do something about it.

In our democracy, such policy must be shaped by the people and their understanding of nature. We must teach about evolution and how it affects us.

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