THINKING SCIENTIFICALLY ABOUT CONTROVERSIAL ISSUES

CLONES, CATS, AND CHEMICALS

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Introduction

Science and technology continue to advance human knowledge at a rapid—some say *too* rapid—pace, challenging accepted beliefs and spurring debate across many fields. Often, it seems scientific research is advancing faster than laws can be created to ensure it proceeds in a safe, humane manner. Human cloning, for example, ignites the passion of both experts and the general population on ethical, moral, religious, economic, and political grounds. All members of society are called upon to make decisions about their health, their recreation, how their actions can affect the environment, whether to play the lottery, whether to support manned or unmanned space flight, whether to seek genetic testing for babies, or how strictly to control violence in the media. These are the issues that are examined in *Clones, Cats, and Chemicals: Thinking Scientifically About Controversial Issues*.

The National Science Education Standards recommend that students have experience grappling with issues that society must ultimately resolve. This publication examines such issues in the fields of biology, chemistry, physics, Earth science, technology, and mathematics. Each issue is presented in two parts: The first part is written for the teacher and contains background on the science of the issue and presents alternative resolutions. The second part is written for the student and may be photocopied and distributed to the class. It includes a brief presentation of the issue and questions or activities to guide the student in the decision-making process.

Teachers should not feel restricted by the questions and activities of each issue, or by the limits of the background. The details of the science and the mood of society that impinge upon the issues change rapidly. For example, Korean researcher Hwang Woo Suk's announcement of having produced a clone of a human blastocyst occurred during the reading of these galley proofs. And President George W. Bush's sudden declaration of plans for a manned flight to Mars within 20 years added political clout to the seemingly stalled manned space program.

It is quite likely that in every school district there are issues that arouse greater interest and passion than do these. Following the format of the topics in this book, however, a resourceful teacher can collect the facts of a local issue and then present the issue to the students to discuss, investigate, and work toward a resolution.

The goal of this publication is to give the science student an opportunity to discuss and investigate the scientific and social issues of concern on a regular basis, and to learn to be comfortable with difficult decisions.

This book was originally published in a previous edition under the title *Real Science, Real Decisions*. I would like to acknowledge the contributions of Jal S. Parakh and John A. Miller, who co-authored some of the pieces in the first edition.

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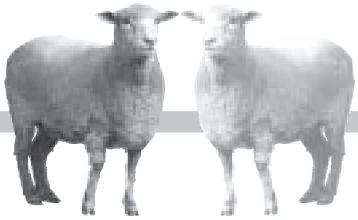


Here Come the Clones

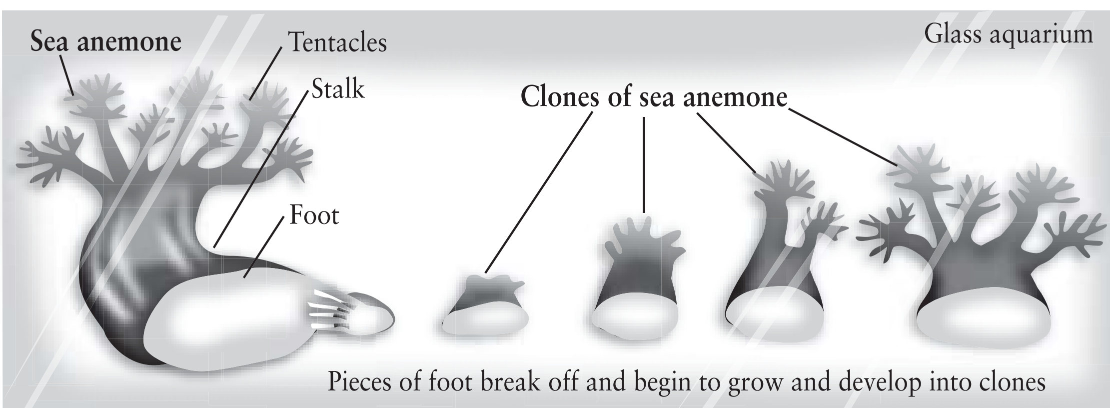
The foot of a sea anemone holds the stalk of the animal to the rocks on a shoreline or to the inside glass walls of an aquarium. As the sea anemone slithers across the rock or glass surfaces, an observer may find that pieces of the tissue of the foot appear to be ripped off the body and adhere as debris to the trail of the slowly moving creature. When one examines these pieces of discarded tissue, at first, they seem to be ordinary adult body cells. But then they appear to change into embryonic cells. Soon the fragments of cells begin to develop and grow into individual sea anemones that are genetically identical to the parent. Zoologists call this natural kind of asexual reproduction *pedal laceration*. All offspring of the parent are clones as they share the same set of genes as the one parent.

Natural cloning is more common among plants. Clones of single parent plants can arise from bulbs, spores, stems, and leaves. Plant breeders may develop a superior variety of apple (Red Delicious) and then, by producing millions of genetically identical trees that grow identically delicious apples, establish a successful fruit market.

FIGURE 1

The cloning (pedal laceration) of a sea anemone

The sea anemone reproduces through the process of pedal laceration, also known as longitudinal fission. As the anemone moves, pieces of the foot break off and develop into genetically identical individuals, or clones. Pedal lacerations are best viewed on the underside of the sea anemone, on the glass wall of an aquarium, for example.



Illustrations by Linda Olliver.

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FIGURE 2

Test-tube cloning of carrots

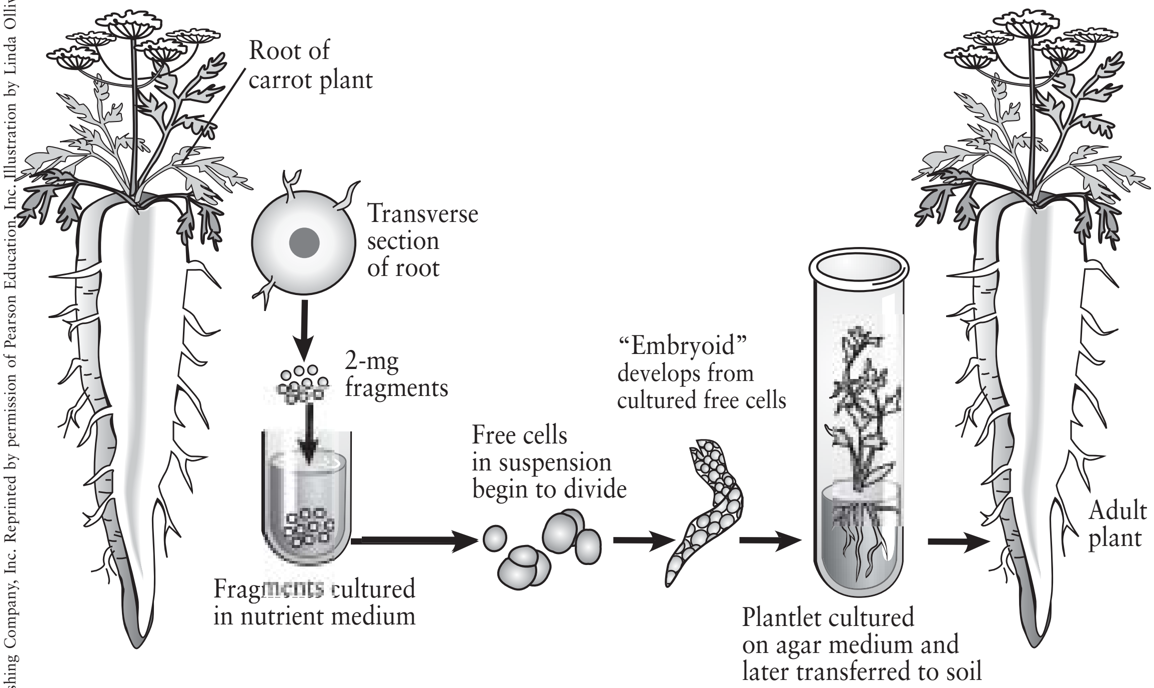
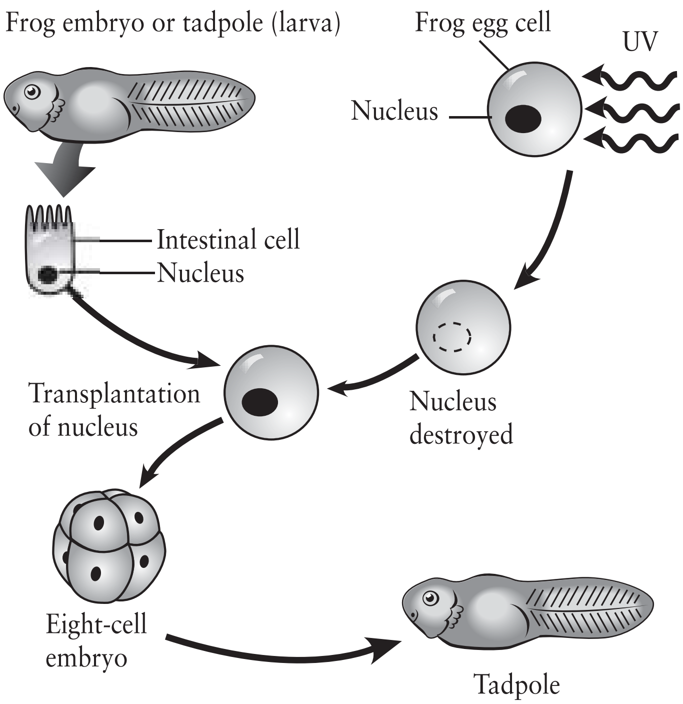


FIGURE 3

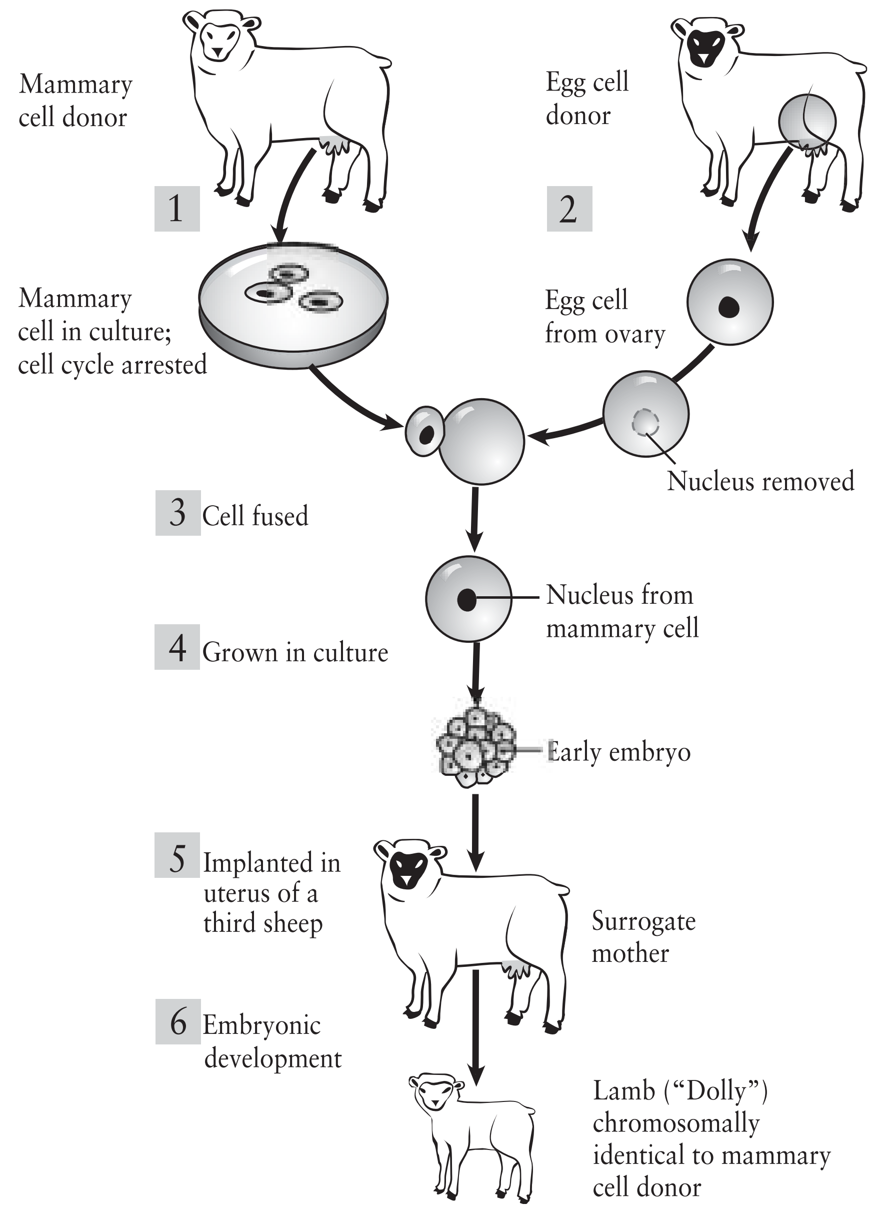
Nuclear transplantation



Well, it’s only human nature to ask, “If sea anemones can clone themselves without hardly trying, and the natural cloning powers of plants are so easily exploited, why can’t we begin learning how to clone ourselves?” The answer to that question is hidden in the secrets of the cell. All plants have one kind of cell that remains forever in the embryonic condition. These cell layers of embryonic tissue are totipotent and can give rise to new differentiated cells. Cut the stem of a plant and these cells will produce root, stem, and leaf tissues. In some animals, totipotent cells—as in the foot of a sea anemone—when cut, will dedifferentiate, and return to an embryonic condition. Then they

Figure 4

Cloning a mammal (Dolly the sheep)



will redifferentiate into foot, muscle, and nerve tissue and the entire organism is cloned.

Could this natural cloning process be duplicated in the lab? At Cornell University in 1950, F. E. Stewart and his team of graduate students took tiny fragments from a fully differentiated root of a carrot and forced it to dedifferentiate into embryonic cells (an embryoid) and then redifferentiate into a fully adult carrot plant.

John Gurdon, a British biologist, pursued the next question: Can a differentiated cell from the intestine of a frog egg dedifferentiate and then redifferentiate into an adult frog? The result demonstrated in 1966 that the younger the totipotent donor cell, the greater the survival of the transplant.

In 1997, Scottish researcher Ian Wilmut and his team announced that they had cloned an adult sheep by transplanting the nucleus from an udder of a mammary gland of an adult sheep into an egg cell from another sheep. The cloned animal, named Dolly, was not identical to the donor mammary cell mother, as the mitochondrial DNA of the egg cell belonged to the egg cell donor. Techniques used by Wilmut to clone the sheep depended upon the breakthrough involved in starving the udder body cell of nutrients, thus interrupting the normal cycle of growth and division of the cell. In this quiet stage the cell can be reprogrammed to function as a newly fertilized egg.

Dolly bred twice, once giving birth to a ewe, and later having three lambs, a ewe and two rams.

Then in 1998, researchers in Hawaii announced that they had cloned 50 mice, using nuclei from ovary cells, and bred the mice for three generations. Since then, numerous mammals have been cloned, including monkeys. Currently there is a strong injunction against the cloning of human beings. Federal funds cannot be used to carry a cloned embryo to term, and private laboratories are under severe pressure not to do so. In February 2004, Korean scientist Hwang Woo Suk announced that his team had successfully cloned human blastocysts and were able to extract viable stem cells that may be used in disease treatment. The scientist stressed, however, that he was against reproductive cloning of humans. Nevertheless, under government sanction or not, someone out there will one day successfully clone a human. And when that occurs, a multitude of questions about the consequences of the event will be asked.

Questions for Discussion

- How will society change under conditions of reproduction by cloning?
- What can happen to the structure of the family?
- What value will sexual reproduction have in the face of the certainties of asexual reproduction?
- Will cloning lead to the loss of diversity, a tendency for homogeneity?
- How can society accommodate a population of clones destined to serve the needs of the few?
- How would the society reorganize itself to include clones of the brilliant, the talented in entertainment, the political leaders, the scientists, and the technicians?

For Further Reading

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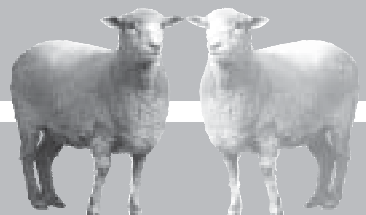

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Are We Ready for Clones?

As late as 1984, scientists David McGrath and Davor Solter wrote in the journal *Science,* "The cloning of mammals by simple nuclear transfer is biologically impossible." That assertion has been proven false, and since that date sheep, mice, cows, monkeys—a virtual menagerie of mammals—have been cloned. A moratorium on the cloning of humans has been enforced by law and by intimidation. Yet the announcement of the first true human clone—from somatic cell and egg cell fusion to embryonic birth—is only a question of time. Whether it occurs in a federal laboratory or in a private clinic, it will happen.

And when it happens, will society be prepared? Here's a hypothetical example: Let's say Clone #1 is successfully created. The clonal cells were stomach cells of a seven-year-old male. The egg cell with the nucleus removed came from a 35-year-old woman. The male donor has a 205 IQ with an interest in astrophysics. The female donor is also unusual with superior skills in Olympic track and field. The embryo developed and the fetus grew in the uterus of a birth mother for nine months. The birth was normal, the child was normal, but from the instance of birth, Clone #1 began a most unusual life.

Who was his father? His mother? What is his name? What is his genealogy? Can he reproduce? Who are his children's grandparents?

Let us now see how his life is developing. First, with whom does he spend his life? With his father and mother, or the nearest relatives? Or, does he become a ward of the state? Harder questions lie ahead. Take on the task of writing the biography of this first human clone. Try to anticipate his experiences as the very first human clone, and possibly his adventures with a new kind of life in an uncharted society. What are his experiences with longevity? Genetic memory? Social action? Social interaction? Marriage?

Now if Clone #1 becomes one of a large population of identical clones performing a task for the good of the community, how is he to be integrated into the society? For example, say Clone #1, along with thousands of nearly identical clones, is selected by society to protect Earth from impending hazards from outer space. Do the clones become human shields, putting their lives at risk to save our own? Or are the clones to be treated as human as anyone else? Or will the clones, by reason of their select superior skills, become the chosen few to make the ultimate decisions and lead the way?

Compose your essay of the world with clones—their impact on us and our impact on them. What will their presence be like? Share your thoughts with the class. Here come the clones, with problems or promises for the future.