3.3 Social and Ethical Issues in Systems Biology

Here is a summary of what you will learn in this section:

- Technological developments in cell biology include gene therapy, cloning, transgenic techniques, and reproductive technologies.
- A systems biology approach views technological developments in the context of social and ethical issues.

Figure 3.27 A surgical team performs a kidney transplant on a patient.

Transplanting Organs

Throwing the first pitch at a major league baseball game is an honour that few people experience. However, on an April day in 2008, 13-year-old Ian Smyth threw the first pitch at the Toronto Blue Jays game in Toronto in recognition of National Organ and Tissue Donation Awareness Week. Ian was seriously ill and had been waiting for a lung transplant for four months. Unfortunately, Ian was just one of 1665 patients in Ontario on the transplant waiting list. Fortunately for Ian, a donor was found and, in May 2008, Ian received a double lung transplant. In 2007, 4195 Canadians were waiting for organ transplants and 193 of those people died while waiting.

The Need for Organs

In Canada, there are about 14 organ donors per 1 million people. Canada's low rate of organ donation is not because Canadians are selfish but because Canadians live relatively healthy lives and have access to better health care. Strategies to obtain more organs for transplants include expanding the acceptable criteria for organ donors and using living donors. For example, since a person can lead a normal life with just one kidney, donating a kidney is the most common living organ donation. Kidney transplantation is the best treatment for people with kidney failure (Figure 3.27). Dialysis, which uses a machine to clean the blood, is the only other treatment (Figure 3.28).

The liver, lung, small bowel, and pancreas can also be donated through living donations. Another strategy to obtain more organs for transplant is using animal-to-human transplants.

There is a shortage of tissues and organs needed for transplantation in all parts of the world. The supply of willingly donated organs simply does not meet the demand. In some countries, individuals are encouraged to sell their organs. For example, in India, poor and destitute people can sell a kidney to patients who are desperate for an organ transplant. The World Health Organization estimates that in 2006, about 6000 people received kidney transplants using kidneys obtained in this manner. The need for organs is so great that some people's organs have been removed without their consent.

Figure 3.28 A person with kidney failure must undergo dialysis or receive a kidney transplant. During dialysis treatment, the blood is passed through a machine to be cleaned.

A28 STSE *Quick Lab*

Organs for Sale?

In 2004, British broadcaster Alistair Cooke died at the age of 95 in New York City. His body was placed in a casket in a local funeral parlour so that friends could visit the parlour and pay their respects to the family. Secretly, the funeral parlour owner had made a deal with a company, known as Biomedical Tissue Services, to sell Mr. Cooke's body parts. His bones were removed and ground up, and used in orthopedic, dentistry, and cosmetic treatments.

Mr. Cooke was actually one of over 1000 cadavers taken from funeral parlours and cemeteries across the Eastern U.S.A. over a period of four years. Since techniques of organ transplantation have improved and the procedure has become more common, the practice of stealing human organs and selling them for profit has been increasing.

In this activity, you will find out current statistics about this practice and consider some of the ethical and social issues that are involved in stealing and selling organs.

Purpose

To describe some of the ethical and social issues involved in the practice of stealing and selling organs

Procedure

1. Your teacher will give you information on the stealing and selling of human organs, such as kidneys.
2. Use your information to complete a 5 Ws graphic organizer.
3. Working in a group of two to four students, discuss your findings. Brainstorm some social and ethical issues that are involved in this practice.

Questions

4. The practice of harvesting organs for sale may involve risky surgery performed in secretive ways. Some people have suggested that legalizing the sale of organs would prevent the physical risks to the organ donor. Comment on this argument.
5. What do you think of the argument that selling and buying organs is a "win-win situation" because it provides money for the donor (seller) and an organ for the buyer? Is this a reason to approve the sale of organs? Explain your answer.

Advances in Cell Biology Technology

Figure 3.29 These mice have an abnormal gene that, without treatment, causes their muscles to waste. They have been treated with gene therapy to see how well their muscles can recover.

Recent advances in cell biology technology have enabled scientists to develop new strategies to treat disease. These advances include gene therapy, cloning, and transgenic and reproductive techniques (Figure 3.29).

There are many points of view that must be considered when applying these advances. Analysis of the societal and ethical implications of each process is an important task for both the scientist and the individual. Society must be continually vigilant to ensure the safe and ethical practices of science. Each of us must learn to think and listen carefully and to speak and act in a moral and responsible fashion.

Gene Therapy

The Human Genome Project (HGP) identified 20 000 to 25 000 genes in human DNA, providing information that makes it possible to cure genetic disorders using gene therapy. Gene therapy involves replacing an absent or faulty gene with a normal gene. For example, gene therapy may be useful in the treatment of cystic fibrosis, a disease in which cells in the lungs produce abnormal secretions that make breathing difficult. **Gene therapy** involves inserting healthy genes so that the cells in the lung function normally.

Currently, gene therapy is an experimental procedure. In the future, gene therapy may be used to treat cancer, inherited diseases, and some viral infections. For example, genes that cause apoptosis could be introduced into cancer cells and cause them to die.

Figure 3.30 shows how gene therapy is supposed to work to correct a genetic abnormality. A virus is used to carry the gene into the cell. The virus is modified so that it cannot cause disease, and the replacement gene is added to its DNA. The modified virus is injected into the patient to carry the gene into cells to correct the defect.

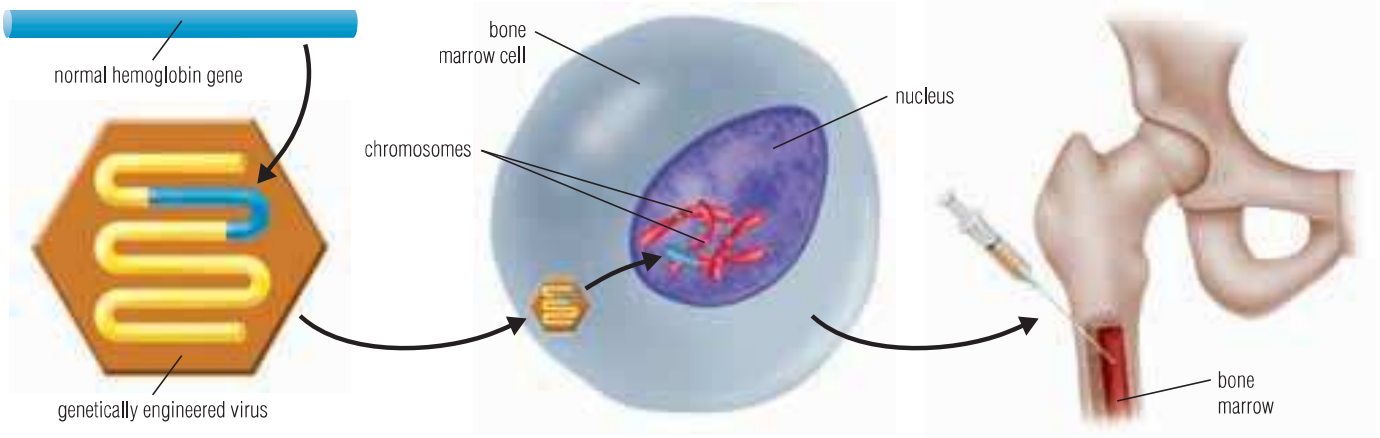

Figure 3.30 Using gene therapy to treat a hemoglobin disease: a virus is used to carry a gene for normal hemoglobin into bone marrow, which is the tissue inside the bone that makes blood cells.

Cloning

Although you may not realize it, you have probably eaten clones — most apples are actually clones. **Cloning** creates a genetically identical organism that is an exact copy of a gene, cell, tissue, or organism.

Figure 3.31 Planting geranium cuttings

Cloning in Plants

The cloning of plants has been done for many years. For example, vegetative propagation involves taking a cutting from a plant and allowing it to root and produce another plant (Figure 3.31). It is also possible to take cells from a root and grow them in culture media to produce cloned plants. Fruit growers have also used cloning in the form of grafting for many years to produce fruit of consistent quality. In grafting, the roots of one type of apple tree are attached to the shoots of another more desirable type of apple tree. Grafting produces trees that all bear the same type of apple.

Cloning in Animals

Much controversy surrounds the cloning of animals. For example, there is research that suggests that cloned animals have genetic diseases. Cloning humans, while theoretically possible, raises additional moral and ethical issues. For example, some people wonder if potential parents would be able to choose, or design, their offspring through the process of cloning.

There are three ways to clone animals: reproductive cloning, gene cloning, and therapeutic cloning. Reproductive cloning involves the transfer of a nucleus from a donor body cell into an egg cell that has no nucleus (Figure 3.32). The egg is transferred to the womb of a mother and begins to grow. The embryo contains genetic information that is identical to the original body cell. This type of cloning may be useful in cloning endangered animals.

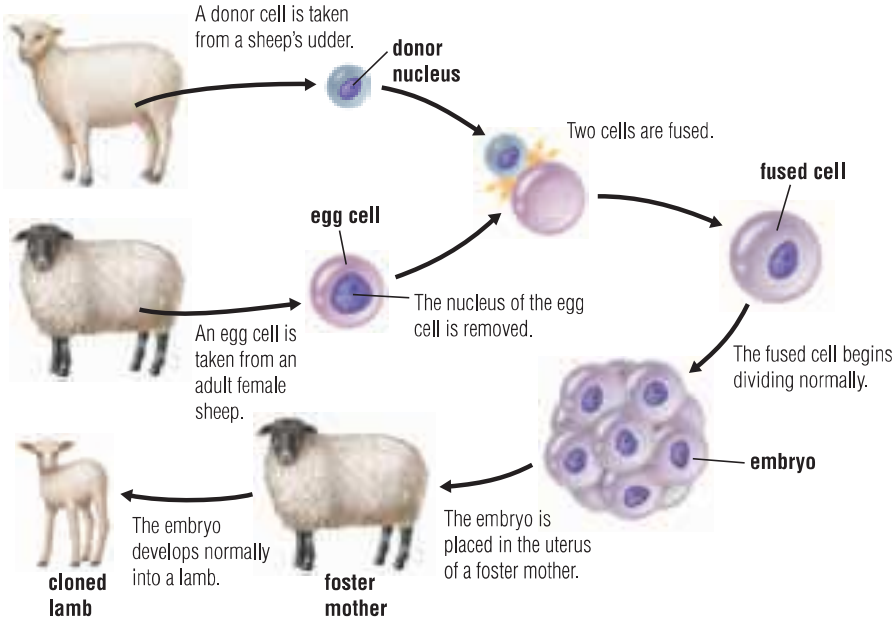

Figure 3.32 In 1997, Dolly the sheep was the first clone of an adult mammal. Monkeys, cows, pigs, dogs, cats, mice, and rats have been cloned using this method.

Gene cloning involves the transfer of a gene into bacteria so that the gene can be reproduced multiple times. By cloning genes, scientists are able to make copies of the gene so that they can do experiments easily. Gene therapy uses this type of cloning.

Therapeutic cloning is similar to reproductive cloning, but the purpose is to harvest embryonic stem cells from a developing embryo. Recall that embryonic stem cells have the ability to produce different types of cells. It is also possible to harvest adult stem cells from bone marrow. The harvested stem cells are used to regrow healthy tissue in place of damaged tissue. This type of cloning may be used to create tissue that is a close match to the patient's tissues. The cells that would be cloned would have the same genetic information as the original tissue. As a result, the newly cloned cells would match the other cells in the tissues and would not be rejected.

WORDS MATTER

The prefix "xeno-" is from the Greek word *xénos*, which means stranger.

Learning Checkpoint

1. What is gene therapy?
2. How can gene therapy be used to treat or prevent disease?
3. What is cloning?
4. Explain how plants are cloned.
5. Distinguish between the three types of cloning of animals.

Transgenic Techniques

Suggested STSE Activity
A30 Decision-Making Analysis on page 119

Goats that produce spider silk in their milk and fish that glow in fluorescent colours (Figure 3.33): these are just two examples of transgenic animals. **Transgenic organisms** contain the genes from other species. Bacteria were the first transgenic organisms. There are many transgenic animals including cows, pigs, mice, rats, chickens, and fish.

There are several uses for transgenic organisms. Transgenic animals can be used to study the effects of diseases. Transgenic animals can also produce organs that can be used in human organ transplants in a process called xenotransplantation. Transgenic livestock may have extra growth hormone to make them grow faster and have leaner muscle.

Transgenic plants have been developed to have an increased resistance to disease or environmental challenges. For example, transgenic crops have been developed to produce a natural insecticide. Some plants, such as golden rice, contain extra nutrients. Transgenic trees contain genes that increase the amount of cellulose, making the timber more desirable to the paper mills.

Figure 3.33 These fluorescent zebrafish, called Glofish™, contain a natural fluorescence gene that causes them to glow.

Reproductive Technologies

Reproductive technologies include a wide range of techniques that can be used to solve fertility problems in domesticated animals, zoo animals, and humans. Reproductive technologies include artificial insemination (AI) and in vitro fertilization (IVF).

Artificial insemination (AI) involves collecting sperm from a male and placing it in the reproductive system of a female. Sperm from human males may be donated and stored in "banks." The use of human sperm and the process of anonymous donation are controlled by government policies. AI is routinely used on dairy and cattle farms. AI has also been used in zoos with some success in Asian elephants and rhinos (Figure 3.34).

In IVF, sperm and eggs are collected and placed in a test tube or petri dish so that fertilization occurs (Figure 3.35). The developing embryos are implanted in the uterus of a female. Multiple embryos are implanted because the chance of success is less than 50 percent.

Ethical Considerations about Reproductive Technologies

Reproductive technologies have brought new ethical considerations, including questions of legal rights and responsibilities. For example, in 2007, a Quebec woman froze some of her eggs so that her daughter could use the eggs to have children in the future. Her daughter is not able to have her own children. The outcome would be that the daughter would bear her mother's children, or her own siblings. Some people argue that it would be wrong for the daughter to bear the child of her mother. Others see nothing harmful in this action. No laws currently exist to provide guidance in this area.

During Writing Thinking Literacy

Consider the Options

A report presents concise information on a number of options and often makes one or more recommendations. Recommendations allow the reader to consider one option that might be better than another and to trace the reasons for choosing that option back through the information in the report.

Figure 3.34 This white rhinoceros calf was born in October 2008 in the Budapest Zoo. His mother, Lulu, was the first rhino to produce a calf through artificial insemination.

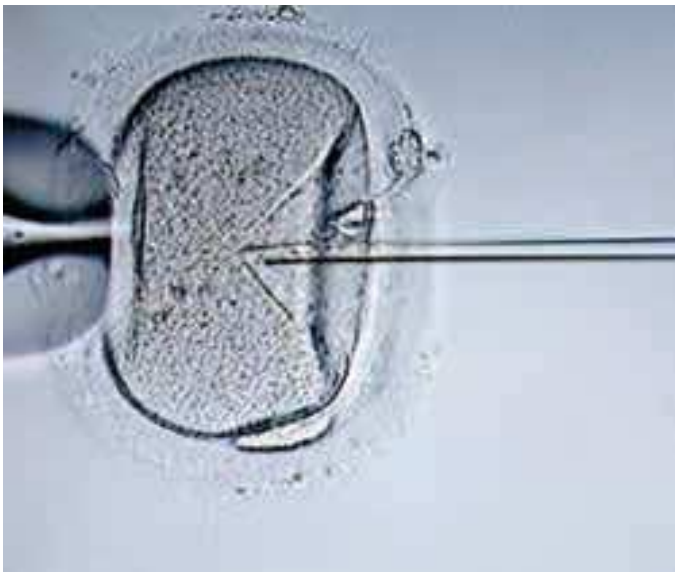

Figure 3.35 A micrograph showing a needle (on the right) about to inject human sperm into a human egg cell.

Take It Further

Dolly was the first mammal cloned from an adult cell. She eventually was able to reproduce. Why is it important that a cloned animal be able to reproduce? Research what happened to Dolly, and learn more about cloned animals. Begin your research at *ScienceSource*.

Another ethical consideration involves whether frozen eggs would be capable of normal growth and development. There is currently not enough research about whether freezing eggs causes genetic damage. In addition, only 5 percent of the frozen eggs used in IVF have resulted in pregnancy. Although companies that promote egg freezing promise that a baby can be made at any time, the statistics do not back that claim.

The use of reproductive technology is associated with various social and ethical considerations including:

- whether the use of the technology is safe
- who owns the technology and the products of the technology
- the standards and codes of practice that are in place for the development and use of the technology
- the definition of life

Learning Checkpoint

1. Define the term "xenotransplantation."
2. What are reproductive technologies?
3. (a) What is artificial insemination?
   (b) Explain how artificial insemination is used.
4. Explain the meaning of "in vitro fertilization."
5. Describe some social and ethical considerations of the use of reproductive technologies.

A29 STSE Science, Technology, Society, and the Environment

Accessing Public Health Programs

You have learned about a variety of public health strategies including programs for immunization and HIV/AIDS education. Public health agencies are concerned with ensuring that programs are accessible and appropriate for everyone.

In this activity, you will complete a "placemat" activity in which you will identify the barriers to accessing appropriate public health services.

1. Working in a group, select one public health strategy to consider. Consider programs such as influenza vaccinations, HPV vaccinations, MMR vaccinations, or HIV/AIDS education.
2. Each member of the group will choose a perspective, such as social, economic, political, environmental, or economic to look at when reviewing the health strategy. For example, if you are looking at the influenza vaccination program, one student will look at the social implications, while another student will look at the political implications.
3. *ScienceSource* Use the links provided to research information about your chosen health strategy. All students in the group will then share their ideas orally with the other members.
4. Write the ideas that are common to the group in the centre of the placemat.
5. Share your findings with the class and your list of "barriers" to accessing appropriate services. As a class, brainstorm some solutions to these problems.