Summary

13–1 Changing the Living World

For thousands of years, people have chosen to breed only the animals and plants with the desired traits. This technique is called selective breeding. Selective breeding takes advantage of naturally occurring genetic variation in a group of living things.

One tool used by selective breeders is hybridization. In hybridization, individuals with different traits are crossed. Hopefully, the offspring will have the best traits of both parents. The offspring of these crosses, called hybrids, are often hardier than the parents.

Once breeders have a group of plants or animals with the desired traits, they want to keep it. To do so, breeders use another tool called inbreeding. In inbreeding, individuals with similar characteristics are crossed. Inbreeding does have the risk of bringing together two recessive alleles for a genetic defect.

Selective breeding would be nearly impossible without large amounts of variation in traits. Breeders can increase the variation in a group of organisms by causing mutations. Mutations are inheritable changes in DNA. Mutations do occur naturally. However, breeders can increase the rate of mutation by using radiation and chemicals. Many mutations are harmful. However with luck, breeders can produce useful mutations.

13–2 Manipulating DNA

To increase variation, scientists can also make changes directly to the DNA molecule. In this group of techniques, called genetic engineering, scientists can change an organism's DNA.

Scientists can easily remove DNA from a cell and separate it from the other cell parts. Scientists can also cut DNA into smaller pieces using enzymes called restriction enzymes. Each restriction enzyme cuts DNA at a specific sequence of nucleotides. These DNA fragments can be separated and analyzed in a process called gel electrophoresis.

Scientists can also read the order of nucleotide bases in a DNA fragment. They use a technique in which a single strand of DNA is copied. However, the copy is made with colored nucleotides inserted at random places. Reading the order of colored bands in a gel gives the nucleotide sequence of the DNA fragment.

Scientists can change DNA sequences in many different ways. Short sequences of DNA made in the laboratory can be joined to the DNA molecule of an organism. DNA from one organism can be attached to the DNA of another organism. These DNA molecules are called recombinant DNA because they are made by combining DNA from different sources.

Scientists often need many copies of a certain gene to study it. A technique called polymerase chain reaction (PCR) allows scientists to do that. PCR is a chain reaction in which DNA copies become templates to make more DNA copies.

13–3 Cell Transformation

DNA fragments cannot work by themselves. They must be part of the DNA molecule in an organism. DNA fragments become part of a cell's DNA during the process of transformation. This is the same process that Griffith observed in his experiments.

To add DNA fragments to bacteria, the fragment is joined to a small, circular DNA molecule called a plasmid. Plasmids are found naturally in some bacteria. Scientists join the fragment to the plasmid by cutting both with the same restriction enzymes. The cut pieces join together because their ends match up.

When scientists transform bacteria, not all bacteria take in the plasmid. Scientists can identify those bacteria that carry the plasmid because the plasmid also carries a genetic marker. Usually the genetic marker is a gene that gives the bacteria resistance to a certain antibiotic.

Plant cells can also be transformed. Scientists insert the DNA fragment into a plasmid. This plasmid is transformed into a bacterium that naturally infects plants. Plant cells in a culture that have had their cell walls removed will also take up DNA on their own. Scientists can also inject DNA directly into some plant cells.

Animal cells can be transformed in ways similar to plant cells. Many egg cells are large enough that DNA can be directly injected into the nucleus. Once inside, the repair enzymes may help insert the DNA fragment into the chromosomes of the injected cell.

13–4 Applications of Genetic Engineering

Scientists wondered whether genes from one organism would work in a different organism. Some scientists isolated the gene from fireflies that allows them to glow. Then they inserted this gene into the DNA of a plant. These plants glowed in the dark. This showed that plants and animals use the same process to translate DNA into proteins. The glowing plant is transgenic because it has a gene from another species.

Human genes have been added to bacteria. These transgenic bacteria are used to produce human proteins such as insulin, human growth hormone, and clotting factor.

Scientists have produced transgenic animals to study the function of genes and to improve the food supply. Transgenic animals might also be used to supply us with human proteins that can be collected in the animal's milk.

Transgenic plants have been produced that can make their own insecticide. Others are resistant to weed killers. Some have even been engineered to contain vitamins needed for human health.

A clone is a member of a population of genetically identical cells that were produced from a single cell. Clones are useful because it is one way to make copies of transgenic organisms. It is easy to produce cloned bacteria and plants.

Animals are very difficult to clone. However, scientists in Scotland have successfully cloned a sheep, named Dolly. Animal cloning has risks. Studies suggest that cloned animals may have genetic defects and other health problems.