

heredity the passing of traits from parents to offspring

genetics the branch of biology dealing with heredity and the variation of inherited characteristics

deoxyribonucleic acid (DNA) a molecule that carries genetic information in cells

gene a segment of a DNA molecule that codes for a particular trait; found at a specific location on a chromosome

locus the location of a gene on a chromosome

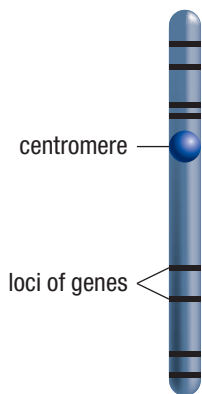


Figure 2 A typical human chromosome contains thousands of genes. Each gene is located at a different locus.

Cell division and reproduction are biological processes that are fundamental to life. All organisms use these processes to grow and reproduce. Multicellular organisms use cell division for growth and repair, whereas unicellular organisms use it as a means of reproduction. A key feature of cell division and reproduction is the passing of chromosomes from the parent cell to the daughter cells. Chromosomes carry information for traits (**Figure 1**). Thus, traits are passed from parents to offspring in a process known as **heredity**.

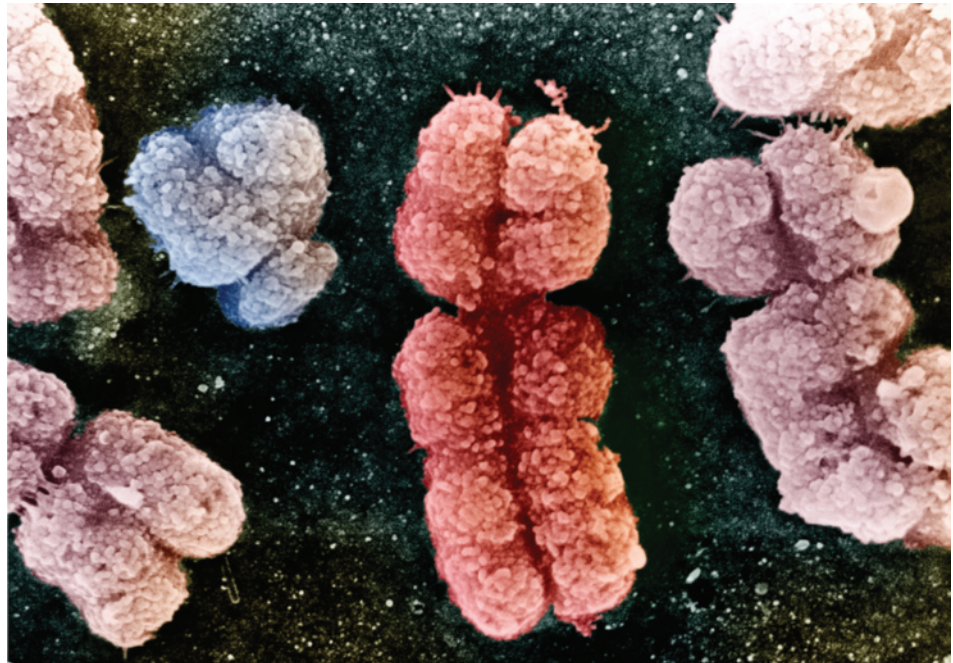


Figure 1 Chromosomes as seen in an early stage of cell division

Genetic Material

Genetics is the scientific study of heredity and variation. Living things inherit traits from their parents—but what causes traits to be passed on from parent to offspring?

Genetic material is a term used to describe all the material in an organism that stores genetic information. In a chromosome, genetic information is contained in a molecule of **deoxyribonucleic acid**, or **DNA**. As you will learn in Chapter 6, our understanding of the structure of DNA, and our ability to manipulate the genetic information it contains, has revolutionized the biological sciences. This knowledge has stemmed from the basic understanding of the organization of genetic material within cells and the mechanisms of heredity from one generation to the next.

Each DNA molecule is composed of hundreds of thousands of chemical subunits that act as a set of chemical instructions for the cell. These instructions occur as distinct sequences of information along the DNA molecule. Each of these distinct sequences of genetic information is called a **gene**. A **gene**, therefore, is a portion of a DNA molecule that carries the information that helps to produce a particular trait of an organism. Each gene occupies a specific location, or **locus** (plural—loci), on a chromosome (**Figure 2**). A typical chromosome carries information for hundreds or thousands of different genes.

When we “inherit” traits from our parents, what we actually inherit is genetic information. This genetic information is contained in segments of DNA called genes, and these genes are located at specific positions along chromosomes. Chromosomes, and all the genetic information they contain, are duplicated during cell division. You will learn more about how this information is passed on to offspring throughout the course of this unit.

Chromosomes

Chromosomes are found in the nucleus of all eukaryotic cells, but vary widely between organisms of different species in their number, shape, and size. Some organisms have few chromosomes in their body cells, while others have many chromosomes in each body cell. Most multicellular organisms have less than 100 chromosomes in the nucleus of each body cell (**Table 1**).

In most multicellular organisms, chromosomes occur in sets. Diploid cells have two sets of chromosomes. Haploid cells have half the normal number of chromosomes. Some cells contain three or more sets of chromosomes and are referred to as **polyploids**.

Although much of the genetic material in a cell is composed of the DNA molecules in its nucleus, both mitochondria and chloroplasts contain small amounts of genetic material. You will learn more about the genetic material found in these organelles in Section 4.5.

Reproduction: Copy or Combine?

Organisms inherit genetic information from their parents. Some organisms have only a single parent (asexual reproduction) while others have two parents (sexual reproduction). How do these different forms of reproduction influence heredity? What are the advantages and disadvantages of one form of reproduction over the other?

Asexual Reproduction

Asexual reproduction is a form of reproduction in which a new individual is produced from a single parent by cell division (that is, without the use of sex cells). While asexual reproduction can vary from species to species (**Figure 3**), it almost always involves cell division. As you may recall, cell division is a cellular process in which the chromosomes of the parent cell are duplicated and then divided such that each of two daughter cells receives one copy of each chromosome. The result is two new cells that are genetically identical to one another and to the parent cell. If one or more of these daughter cells develops into a new, independent individual, the result is asexual reproduction. The production of genetically identical offspring is a key distinguishing feature of asexual reproduction.

There are several biological advantages to asexual reproduction. The parent organism does not have to seek out a mate, perform specialized mating behaviours, or possess specialized anatomy. In this way, nothing seems left to chance—asexual reproduction results in heredity that is direct and invariable. Generation after generation, offspring remain genetically identical to their parents.



Figure 3 Known as the “mother of thousands” plant, *Kalanchoe daigremontiana* produces asexual “baby” plants along the edges of its leaves.

Table 1 Chromosome Numbers in Assorted Species

Species	Number of chromosomes per body cell
human	46
dog	78
mosquito	6
banana	22

polyploid having more than two sets of chromosomes; many plants are polyploids

asexual reproduction the production of offspring from a single parent; the genetic makeup of the offspring is identical to that of the parent

sexual reproduction the production of offspring from the fusion of two sex cells (usually from two different parents); the genetic makeup of the offspring is different from that of either parent

Sexual Reproduction

Sexual reproduction is a form of reproduction in which individuals are produced from the fusion of two sex cells. The sex cells usually, but not always, come from two different parent organisms. Offspring produced by sexual reproduction are not genetically identical to either of their parents and are rarely genetically identical to each other. Instead, they obtain half of their genetic information from each of their two parents. Sexual reproduction results in offspring that are genetically variable and contain equal amounts of genetic information from each of two parents.

There are a number of disadvantages to sexual reproduction. For example, animals and other organisms that reproduce sexually must have specialized organs to produce sex cells. In animals, producing mating calls or being brightly coloured can help attract a mate—but can also attract predators. In plants, producing flowers attracts pollinators like bees, but also requires the production of nectar. Sex is biologically “costly” and potentially risky (**Figure 4**). In addition, it is possible that the offspring may inherit a combination of genetic information that makes them weak and possibly unable to survive.



Figure 4 (a) An adult male moose grows a new and impressive set of antlers each year. Energy and nutrients are required for this process. (b) A peacock (a male peafowl) grows ornate tail feathers to attract peahens. This can be a disadvantage when it comes to avoiding predators.

Why, then, do so many of Earth’s organisms participate in some form of sexual reproduction? What is it about producing genetically variable offspring that creates a benefit worth the cost in time, energy, and resources?

The answer to these questions lies not solely with the individuals themselves but also with their surroundings. If individuals were to rely on asexual reproduction only, their descendants would remain almost genetically identical over countless generations. This might be beneficial if the original parent is well adapted to its environment and its environment is unchanging. However, this is rarely the case. Environments change, and these changes can be sudden: a fire, a volcanic eruption (**Figure 5**), or the introduction of a new disease or competitor. For example, if a new disease infects one individual, it could quickly infect virtually all individuals if they are genetically identical. This can be a significant problem in agriculture when plants are grown as monocultures—crops of a single species. Changes can also be slow and gradual: mountain formation, climate change, the evolution of a new species, or an old species slowly going extinct.

While asexual reproduction produces invariable offspring, this creates its own risk: if and when the environment changes, the individuals may no longer be well adapted. In contrast, sexual reproduction presents a different approach—the production of variable offspring, which may provide some insurance or flexibility into the future. Here, variability plays a prominent role; some offspring may not be well adapted for change, while others may be better adapted than their parents to a new environment. In the sections and units that follow, you will explore the relationships between reproduction, heredity, and the environment.



Figure 5 Volcanic eruptions can result in the destruction of previous ecosystems and the creation of new uninhabited ones.

4.1 Summary

- A fundamental aspect of reproduction is the passing on of genetic information from one generation to the next.
- Genetic information is stored in DNA molecules within the chromosomes of cells.
- Portions of the DNA molecule, called genes, carry heritable information and are found at distinct locations on a chromosome.
- Chromosome number, shape, and size vary from species to species.
- Asexual reproduction results in offspring that are genetically identical to their single parent.
- Sexual reproduction results in offspring that are genetically variable. Offspring inherit half of their genetic information from each of two parents.

4.1 Questions

1. In your own words, describe the relationship between each of the following pairs of terms: **K/U A**
 - (a) reproduction and heredity
 - (b) DNA and chromosomes
 - (c) genetic information and gene
 - (d) diploid and haploid
2. Draw a labelled sketch of a single chromosome, identifying as many of the structures discussed in this section as possible. How many chromosomes are found in a single human body cell? **K/U C**
3. (a) Use the Internet to research and compare the diploid numbers of the following pairs of species: **K/U T/I A**
 - (i) lion and tiger
 - (ii) elephant and woolly mammoth
 - (iii) chimpanzee and gorilla
 - (iv) dog and wolf
 - (v) wolf and red fox**C A**
 - (b) What do you notice about chromosome number and the similarity of these species?
 - (c) Choose any two other “pairs” of animals and compare their chromosome numbers. Comment on your findings.
4. Use a Venn diagram or chart to compare heredity in asexual and sexual reproduction. **K/U C**
5. List several biological advantages of asexual reproduction. Explain your reasoning. **K/U A**
6. Describe the added “costs” of sexual reproduction for an organism. **K/U**
7. When is the production of genetically identical offspring a disadvantage? Explain your reasoning. **K/U A**
8. (a) Brainstorm several examples of environmental changes not mentioned in the text that are
 - (i) sudden and rapid
 - (ii) slow and gradual
 - (b) For each change, consider how the change might differently impact species that are reproducing sexually compared to those that are reproducing asexually. **T/I A**
9. Moose antlers and peacock tails are classic examples of features related to sexual reproduction. Explain what advantages and disadvantages might be associated with each of the following: **A**
 - (a) mating calls of birds
 - (b) release of chemical scents into the air by female moths
 - (c) the very large size of male elephant seals compared to females
 - (d) the production of nectar by many flowers
10. Look at the butterfly in **Figure 6**. It has inherited an interesting set of markings on its body and wings. **K/U T/I A**
 - (a) How might such an inherited feature benefit the butterfly?
 - (b) Do you think it is possible for this inherited feature to help the butterfly reproduce? Why or why not?



Figure 6



GO TO NELSON SCIENCE