UNIT 7

Cell Division, Genetics, and Molecular Biology

General Outcomes

In this unit, you will

- describe the processes of mitosis and meiosis
- explain the basic rules and processes associated with the transmission of genetic characteristics
- explain classical genetics at the molecular level

Unit Contents

Focussing Questions

1 What processes contribute to genetic variation?

2 Why do you and other organisms inherit some characteristics and not others?

3 How did scientists discover the structure of DNA, and how do they use technology to change that structure to produce new varieties of organisms?

Unit PreQuiz

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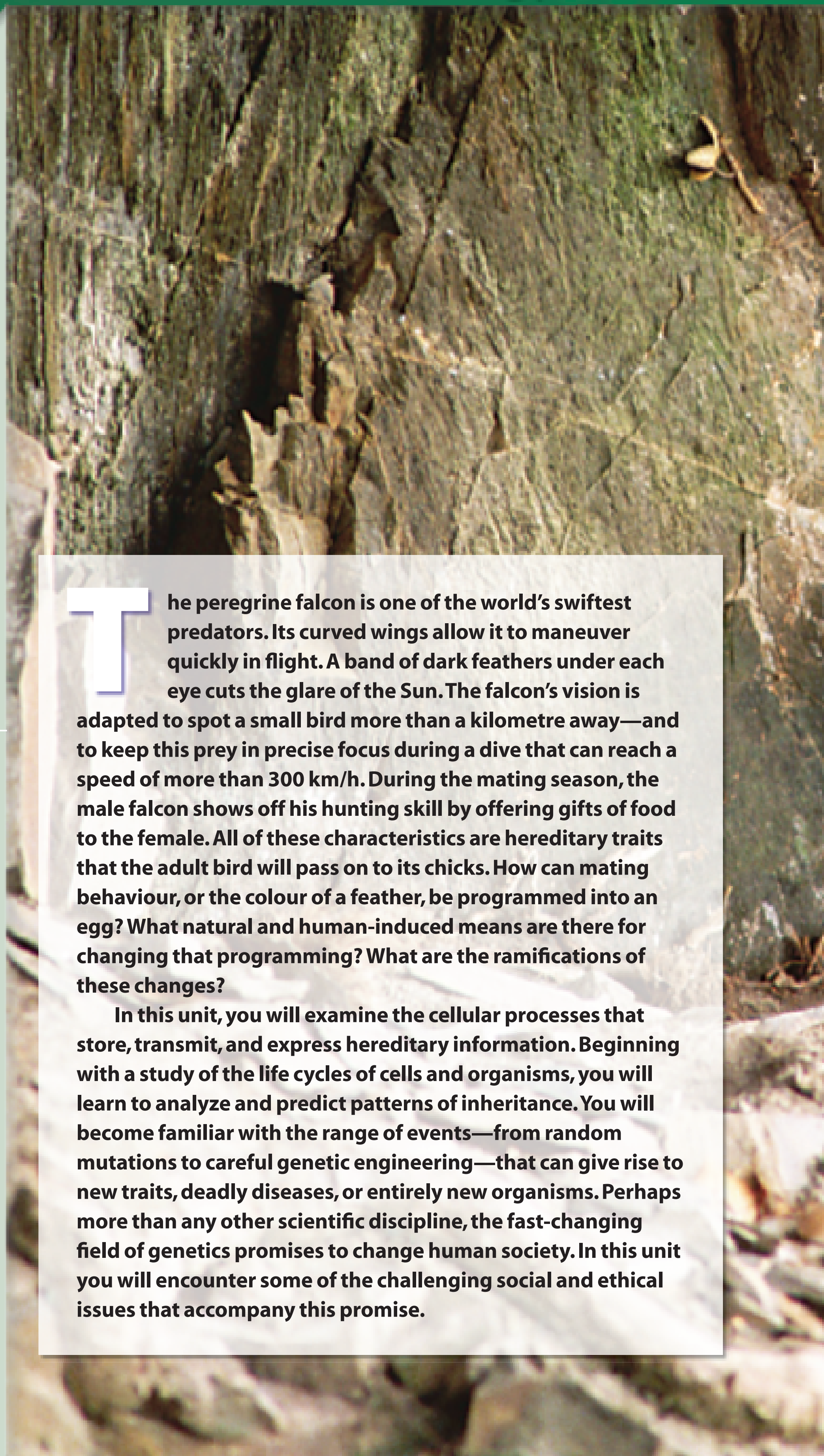

The peregrine falcon is one of the world's swiftest predators. Its curved wings allow it to maneuver quickly in flight. A band of dark feathers under each eye cuts the glare of the Sun. The falcon's vision is adapted to spot a small bird more than a kilometre away—and to keep this prey in precise focus during a dive that can reach a speed of more than 300 km/h. During the mating season, the male falcon shows off his hunting skill by offering gifts of food to the female. All of these characteristics are hereditary traits that the adult bird will pass on to its chicks. How can mating behaviour, or the colour of a feather, be programmed into an egg? What natural and human-induced means are there for changing that programming? What are the ramifications of these changes?

In this unit, you will examine the cellular processes that store, transmit, and express hereditary information. Beginning with a study of the life cycles of cells and organisms, you will learn to analyze and predict patterns of inheritance. You will become familiar with the range of events—from random mutations to careful genetic engineering—that can give rise to new traits, deadly diseases, or entirely new organisms. Perhaps more than any other scientific discipline, the fast-changing field of genetics promises to change human society. In this unit you will encounter some of the challenging social and ethical issues that accompany this promise.

UNIT 7 Preparation

Prerequisite Concepts

This unit draws and builds upon your understanding of biodiversity from Chapter 3 as well as from earlier studies.

The Chemical Codes of Cells

Nucleic acids are biological chemicals that direct the growth and development of every single-celled and multi-celled organism by means of a chemical code. These chemicals determine how the cell functions and what characteristics it has. The cell contains two types of nucleic acid: RNA (ribonucleic acid) and DNA (deoxyribonucleic acid). DNA is the main component of the genes (hereditary material) in all cells. Each gene contains instructions for making RNA, which contains the instructions for making proteins. These proteins make up much of the structure of a cell and control how it functions.

Prokaryotes and Eukaryotes

The smallest cells with the simplest type of internal organization lack a nucleus. That is, they lack an enclosed region inside of the cell where the DNA is separated from the rest of the cell. Instead, the DNA in these cells is concentrated in one region inside the cell. Such cells are called prokaryotes ("pro" meaning before and "karyon" meaning nucleus). Prokaryotic organisms are divided into two domains—Bacteria and Archaea—as shown in Figure P7.1.

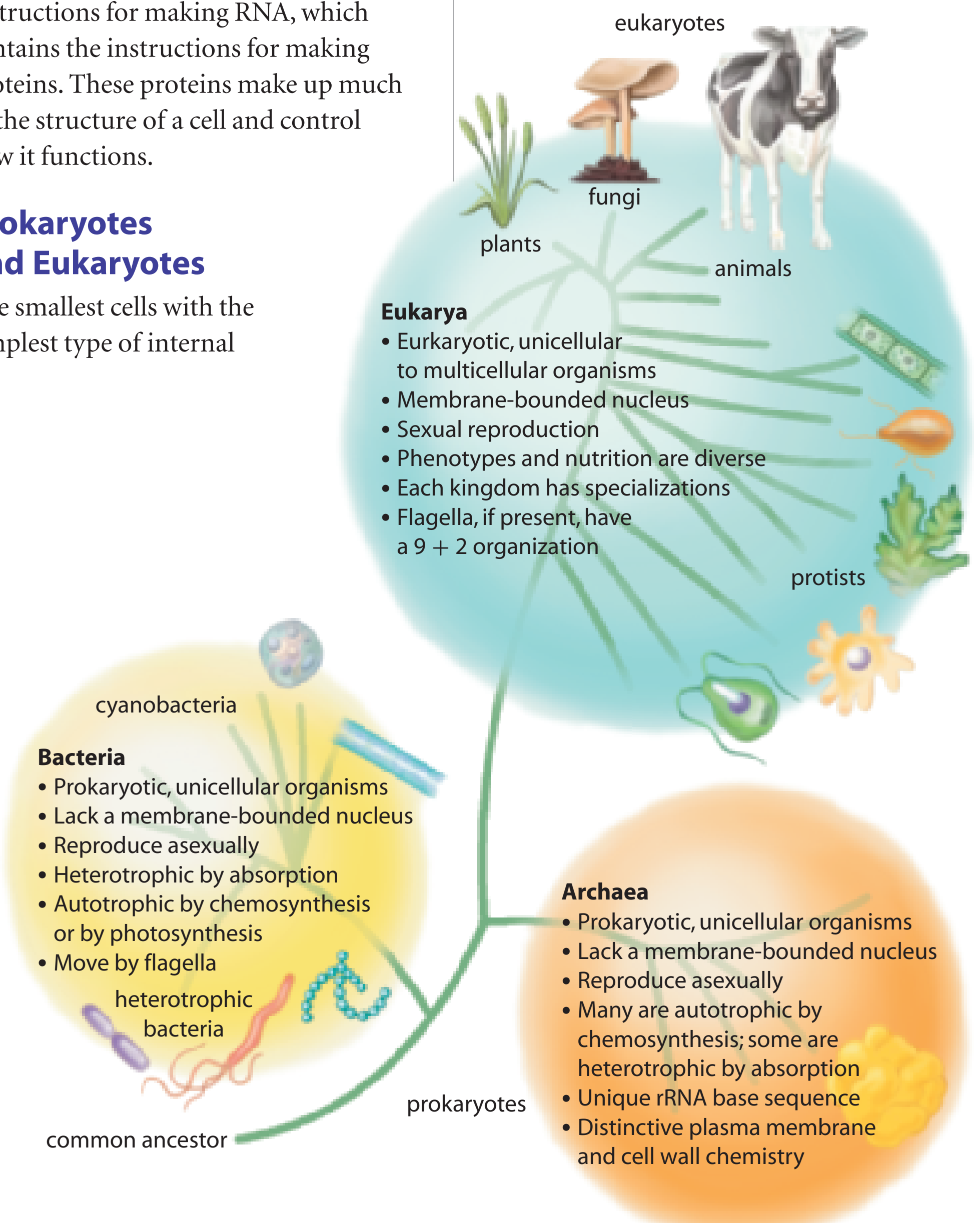

Figure P7.1 Two of the three domains of life contain prokaryotic organisms. The remaining domain contains eukaryotic organisms, including humans.

The cells of all other organisms are larger than prokaryotes and have a more complex structure that includes a nucleus. Such cells are called eukaryotes ("eu" meaning true, as in "true nucleus").

The organelles of a eukaryotic cell divide its interior into compartments. This allows the many different chemical reactions constantly taking place within the cell to proceed at the same time without interfering with one another. Many organelles contain highly folded membranes that increase the surface area on which chemical reactions can be co-ordinated as well as the overall rate of reactions within the cell.

The Nucleus and Ribosomes

The genetic information stored in the DNA (Figure P7.2) determines the structural characteristics of the cell and how it functions. Unless a cell is in the process of dividing or preparing to divide, the DNA exists in a network of strands called chromatin.

The nucleus has at least one area of chromatin, called a nucleolus, that is dedicated to producing a special type of RNA that is used to construct the many ribosomes required by the cell.

Ribosomes are tiny organelles that are the sites of protein synthesis in cells. Ribosomes are found in both eukaryotic and prokaryotic cells. In eukaryotes, ribosomes are 20 nm to 30 nm in diameter; they are slightly smaller in prokaryotes. In both types of cells, ribosomes are made up of two subunits, one large and one small, each with its own mix of proteins and RNA.

The nucleus is separated from the cytoplasm by a double membrane called the nuclear envelope. This membrane has nuclear pores about 100 nm in diameter that permit the passage of proteins into the nucleus and ribosomal subunits of the nucleus.

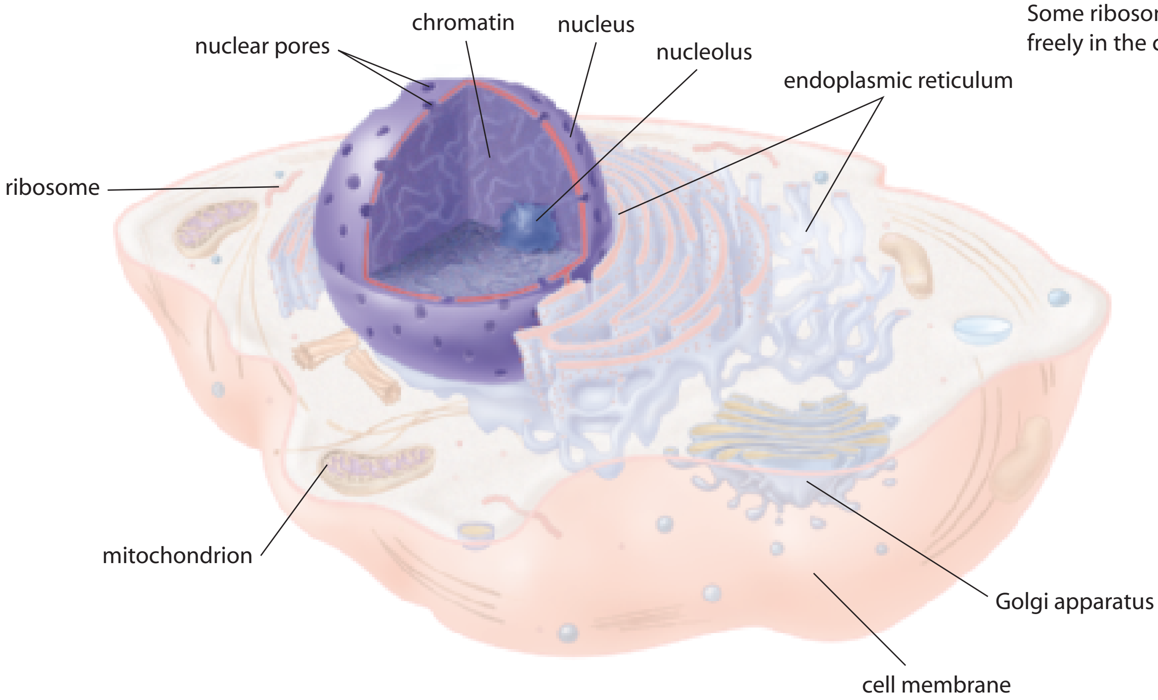

Figure P7.2 The cell nucleus and related structures. Continuous with the outer membrane of the nuclear envelope is a system of flattened membrane-bound sacs, the endoplasmic reticulum, studded with protein-synthesizing ribosomes. Some ribosomes also float freely in the cytoplasm.