

PREFACE

The book you are about to read probably costs the same as a night on the town or a single top-of-the-line athletic shoe. Is it worth it? That depends on what you expect to get out of a course in general biology. More than this, it depends on what you expect to get out of life.

Reading *Biology: Concepts and Applications* is like having your own private audience with biologists from colleges, universities, and research laboratories the world over. The book contains insights from about 2,000 biologists who contributed time and energy to its development over the past two decades—insights that can sharpen your view of life. The biological perspective happens to be one of the most useful tools for interpreting the world. With it, you can cut your own intellectual paths through social, medical, and environmental thickets. With it, you can come to understand the past and to predict possible futures for ourselves and all other organisms.

Writers who mean to do justice to the biological perspective know they must use the principles of biochemistry, inheritance, and evolution as the framework for a book. They also should convey the great power of evolutionary theory to explain life's unity and diversity by incorporating examples of problem solving and experiments. They should identify key concepts for all major fields of inquiry and select topics to give students a sense of current understandings and research trends. They should explain the structure and functioning of a broad sampling of organisms in enough detail so that students can develop a working vocabulary about life's parts and processes. Besides all of this, they must write in a way that is logical, clear, engaging, and never patronizing.

We met four more objectives for this latest revision of *Biology*. We recast the book in a modular format. We refined and updated its core material and applications. We started each chapter with a short story that leads to the chapter's key concepts in an informative yet entertaining, nonthreatening way. Finally, we created many more visual summary illustrations, which have a track record of helping several million of our student readers work their way through difficult concepts.

CONCEPTUAL FLOW THROUGH A MODULAR FORMAT

The book's *numbered, modular format* is the most significant departure from preceding editions. These modules give instructors far more flexibility in assigning or skipping different sections of each chapter. The advantages are so great that most introductory textbooks probably would be structured this way—if it were easy to modularize chapters without chopping up their story lines. Even though we have more than twenty years of experience in writing and illustrating biology textbooks, the structuring turned out to be an astonishing challenge. Yet we believe that the results move the book to a new, more effective level of pedagogy.

3.1 BASIC ASPECTS OF CELL STRUCTURE AND FUNCTION

Inside your body and at its moist surfaces, trillions of cells live in interdependency. In stummy pondwater, a single-celled amoeba moves about freely, thriving on its own. For humans, amoebas, and all other organisms, the cell is the smallest entity that still retains the properties of life. A cell either can survive on its own or has the potential to do so. Its structure is highly organized, and it engages in metabolism. A cell senses and responds to specific changes in the environment. And it has the potential to reproduce itself, based on inherited instructions in its DNA.

Structural Organization of Cells

Cells differ enormously in size, shape, and activities, as you might gather by comparing a bacterium with one of your liver cells. Yet they are alike in three respects. All cells start out life with a plasma membrane, a region of DNA, and a region of cytoplasm:

1. **Plasma membrane.** This thin, outermost membrane maintains the cell as a distinct entity. By doing so, it allows metabolic events to proceed apart from random events in the environment. A plasma membrane does not isolate the cell interior. Substances and signals continually move across it, in highly controlled ways.
2. **DNA-containing region.** DNA occupies part of the cell interior, along with molecules that can copy or read its hereditary instructions.
3. **Cytoplasm.** The cytoplasm is everything enclosed by the plasma membrane, except for the region of DNA. It is a semifluid substance in which particles, filaments, and other compartments are organized.

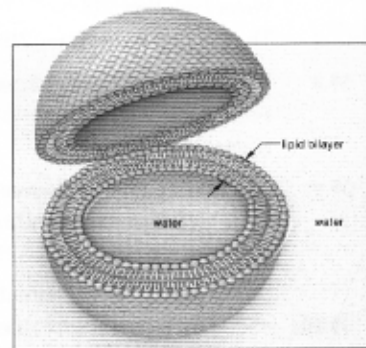
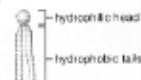
This chapter introduces two fundamentally different kinds of cells. **Eukaryotic cells** contain distinct arrays of organelles—tiny, internal sacs and other compartments formed from membranes. One organelle, the nucleus, houses the DNA. It is the defining feature of eukaryotic cells. By contrast, **prokaryotic cells** have no nucleus; no membranes intervene between the region of DNA and the cytoplasm that surrounds it. Bacteria are the only prokaryotic cells. Beyond the realm of bacteria, all other organisms—from amoebas to peach trees and puffball mushrooms to zebras—are eukaryotes.

The Lipid Bilayer of Cell Membranes

A cell's organization and activities depend on its membranes. If any membrane is to function properly, fluid must bathe its two surfaces. How, then, does it remain structurally intact? Is it like a solid wall separating two fluid regions? Not at all. Push a fine needle into and out of a cell, and cytoplasm will not ooze out. Instead, the

cell surface will flow over the puncture and seal it. The plasma membrane apparently shows fluid behavior!

How do "fluid" cells remain distinct from their fluid surroundings? For the answer, let's start by looking at phospholipids—the most abundant component of any cell membrane. A **phospholipid**, recall, is a molecule having a hydrophilic (water-loving) head and two fatty acid tails, which are hydrophobic (water-dreading). If you immerse many phospholipid molecules in water, they will interact with the water molecules and with one another until they spontaneously cluster together. Collectively, the jostlings might even force them to become arranged in two layers, with the fatty acid tails sandwiched between the hydrophilic heads. This arrangement, which is called a **lipid bilayer**, is the structural basis of cell membranes.



So why does a punctured membrane seal itself? A puncture is energetically unfavorable; it exposes many hydrophobic groups to water. Mutual repulsion forces the phospholipids back to the more stable arrangement.

Fluid Mosaic Model of Membrane Structure

Figure 3.2 shows a bit of membrane that corresponds to the **fluid mosaic model**. By this model, cell membranes consist of lipids and proteins. They incorporate a variety of phospholipids, glycolipids, and sterols (such as cholesterol in animals and phytosterols in plants). Many proteins are embedded in the bilayer or positioned at

FIGURE A A module from this edition.

As the sample in Figure A shows, each module starts with a clearly numbered heading, and it ends with boldface summary statements to reinforce the key concepts. Each is self-contained on one or two pages—yet careful transitions allow all the modules of a chapter to flow smoothly, one into the other, so students won't lose sight of the big picture.

Each module contains all the text and illustrations for a particular topic, so students can work their way through one topic at a time without those annoying page-flipping searches for information.

Unless writers know what they are doing, they run the risk of having a modular format dictate content, like a tail wagging the proverbial dog. Fortunately, we had a history of being full-time fanatics about crafting the text, art, and

captions for each chapter into an integrated story. When we decided to learn Quark for this edition, it was with the understanding that page makeup should not supersede our craft but rather should be an extension of it.

We quickly learned that you can't write good modules without clearing the clutter from your mind, for there simply is no room for superfluous detail. Where details are useful as expansions of key concepts, we often integrated them into suitable illustrations rather than allowing them to disrupt the text flow. We blocked out section headings and subheadings in order to rank the importance of bits of related information. Any good story has such a hierarchy of information, with background settings, major and minor characters, and high points and an ending where everything comes together. Without a hierarchy, information has all the excitement, flow, and drama of an encyclopedia. Additionally, we refined the paragraphs and carefully adjusted the size of photographs and line art. As part of the creative fine-tuning, we also introduced variations in page layouts to avoid the monotonous, encyclopedic look that tend to make student readers wonder whether they are brain dead.

Finally, we understand fully that many students approach biology textbooks with apprehension. If the words don't engage them, they sometimes end up hating both the book *and* the subject. It comes down to line-by-line judgment calls. Having devoted years to writing precisely and objectively, we have a strong sense of when to leave core material alone and when to loosen it up to give students breathing room. Interrupting, say, the description of mitotic cell division with a distracting anecdote does no good. Plunking a humorous aside into a chapter that ties together the evolution of the Earth and life trivializes a magnificent story. By contrast, it certainly is appropriate to follow modules on mitotic cell division with a brief look at the cell cycle and cancer. It is fine to entertain students *if* doing so reinforces key concepts, as with the story of the misguided species introduction that allowed rabbits to rampage through much of Australia or the story of how artificial selection produced bulldogs, which sometimes pass out because the overly wide, flabby roof of their mouth does not favor easy breathing.

The result is that students get the best of both worlds—appropriate, engaging content *and* cleanly served-up content—one module at a time.

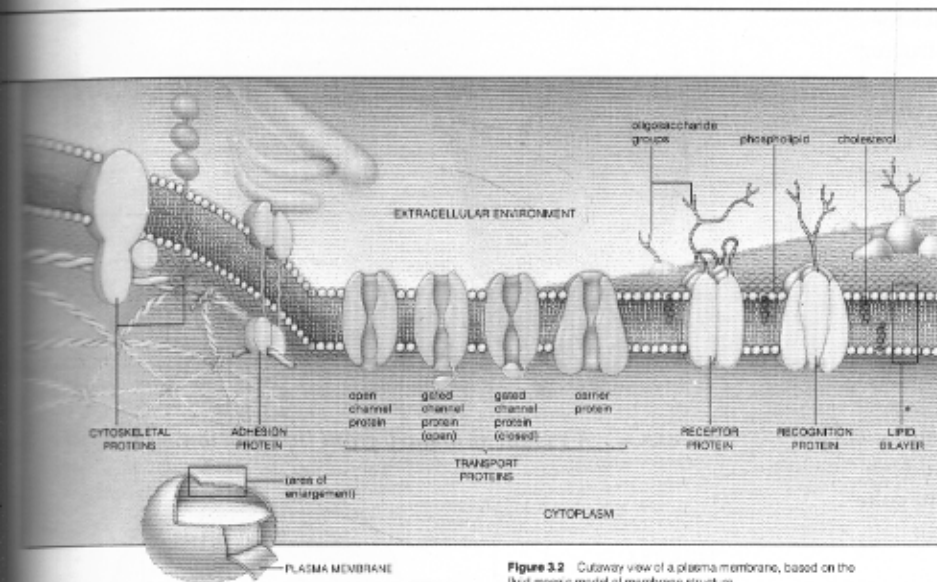


Figure 3.2 Cutaway view of a plasma membrane, based on the fluid mosaic model of membrane structure.

one of its surfaces. Different events proceed at the two surfaces, which differ in the number, kind, and arrangement of their lipids and proteins.

The term "mosaic" refers to the mixed composition of lipids and proteins. "Fluid" refers to the motions of lipids and their interactions. Phospholipid molecules spin about their long axis, they move sideways, and their tails flex—all of which helps keep neighboring molecules from packing into a solid layer. Lipids that have short tails or unsaturated (kinked) tails contribute to the membrane's fluidity.

Proteins associated with the bilayer carry out most membrane functions. Various **transport proteins** allow or encourage water-soluble substances to move through their interior, which opens on both sides of the bilayer. These proteins bind molecules or ions on one side of the membrane, then release them on the other.

Receptor proteins bind hormones and other extracellular substances that trigger changes in cell activities. For example, enzymes that crank up machinery for cell growth and division are switched on when a hormone (such as somatotropin) binds to receptors for it. Different cells have different combinations of receptors.

Diverse recognition proteins at the cell surface are like molecular fingerprints; they identify a cell as being

of a specific type. For example, "self" proteins pepper the plasma membrane of your body's own cells. Certain white blood cells chemically recognize these proteins and leave your cells alone. But they will launch attacks against bacterial cells, viruses, and other invaders that have "nonself" proteins at their surfaces.

Finally, in multicelled organisms, **adhesion proteins** help particular kinds of cells stick together and thereby remain positioned in their proper tissues.

All cells have an outermost, **plasma membrane**, an internal region of cytoplasm, and an internal region of DNA.

Besides the plasma membrane, eukaryotic cells have internal, membrane-bound compartments, including the nucleus.

Each membrane has a **lipid bilayer**. The hydrophobic parts of its lipid molecules are sandwiched between the hydrophilic parts, which are dissolved in the fluid surroundings.

The lipid bilayer gives the membrane its basic structure and serves as a barrier to water-soluble substances.

Proteins associated with the bilayer carry out most membrane functions. Many types transport substances across the bilayer or serve as receptors for extracellular substances. Other types function in cell-to-cell recognition or adhesion.