Visualizing Cell Processes

A Series of Five Programs
produced by BioMEDIA ASSOCIATES

Content Guide for Program 1
“Cells and Molecules”

Each of the five video programs in this set consists of a series of short, narrated, full-motion modules 1-3 minutes long. Each module conveys an essential process of cellular biology or, in the case of the opening module, an overview that will serve as an organizer for the modules that follow in this series. The modules are organized around the national standards for teaching biology, grades 10-14.

cell cutaway from color illustration in program

The Cell Machinery — Module #1.

Christian de Duve, a pioneering cell biologist, likens a cell to a cherry. The cherry skin represents the plasma membrane. The juicy pulp—the cytoplasm and cytosol. The pit represents the cell nucleus. All nucleated cells, from those the two hundred or so kinds that make up a human body to the protozoan and algae cells that live independent lives in ponds and oceans, have this cherry-like organization.

Looking closer, as with an electron microscope, we see that the plasma membrane, the cell's outer envelope, is a double layer of lipid molecules, the molecules in each layer shifting and trading places thousands of times a second, giving the membrane tremendous fluidity while still enclosing and protecting the cell content from a hostile outer world. The details are illustrated in programs *#2 Cell Movement and Transport.*

Surrounding a cell's nucleus are more folded membranes. These are studded with small bodies made of RNA—the ribosomes—protein synthesizing machines that make up the rough endoplasmic reticulum (rough ER). To examine this complex, but highly efficient assembly line, see program *#5 The Genetic Code and Its Translation.*

Once manufactured, molecules are packaged in membrane sacs for transport around the cell (and also for export) by the Golgi apparatus—a sort of shrink wrapper for the cell's molecular products. One membrane-bound package is potentially deadly—the lysosome, a sac of digestive enzymes that if released into the cytoplasm would digest the cell from the inside. But the packaging is robust and lysosomes move about the cell, engulfing and digesting worn out parts, or in the case of cells that engulf bacteria and other food items (amoebas and certain white blood cells), the enzymes are put to work breaking down the food in "cell stomachs" called secondary lysosomes, or food vacuoles. (see Program *#2 Cell Movement and Transport*)

Energy for cell processes is supplied by two kinds of cell organelles—chloroplasts and mitochondria. **Chloroplasts** found in plant and algae cells convert light energy into chemical energy required for cell work. Much of this energy is used to synthesize the molecular building blocks from which the cell assembles its proteins, fats, carbohydrates, and nucleic acids. Fats and carbohydrates can be digested and their building blocks fed into **mitochondria** where they are enzymatically broken down and their energy transferred to the high energy chemical bonds of ATP, life's universal energy carrier. Cells that don't have chloroplasts (animal cells, fungi cells, and many kinds of protists), must harvest food molecules made by cells that do—giving their mitochondria fuel, assuring their own supplies of ATP. These fundamental processes are the topics of Program *#3 Photosynthesis and Cellular Respiration.*

All of this complex cell machinery exists within the cell's structural framework, a "cytoskeleton" composed of protein girders and cables. These structures, mostly too small to see with a light microscope, give cells their shapes, while allowing great flexibility. One type of cable, microtubules, create the internal transport systems needed for virtually all cell functions. *(Program #2)*

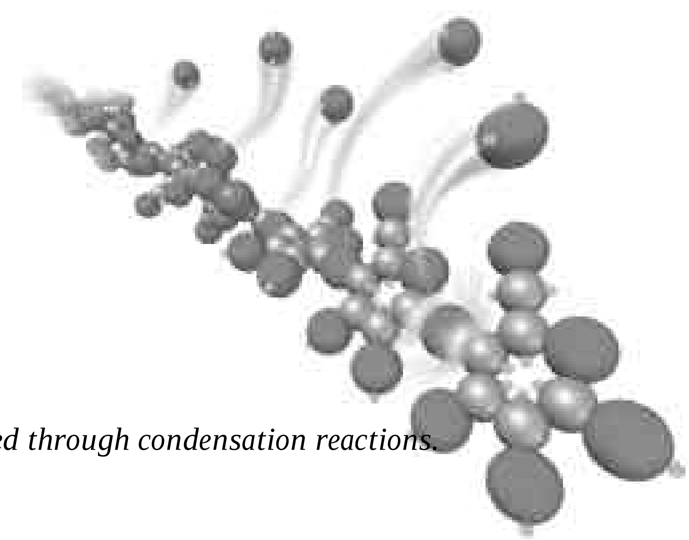
The nucleus contains the cell's DNA, a genetic blueprint for the species, a set of genetic instructions that must be copied faithfully with each cell reproduction. Eukayotes with their multiple chromosomes use the elaborate sorting processes of mitosis and meiosis to pass on genetic information virtually error free (see program #4 *DNA Replication and Cell Reproduction*). But, to communicate genetic instructions involves transcribing them to messenger RNA, sending the RNA copy through special pores in the membranes that make up the nuclear envelope and then translating the code for a particular protein—a process that occurs on the ribosomes. Many of these proteins are the organic catalysts that mediate and control the chemical processes of life. How these "enzymes" are made is treated in Program #5.

A Variety of Cells, — Module #2

Two cell types dominate life on Earth: Prokaryotic cells, such as archaea and bacteria (cells without nuclei), and Eukaryotic cells (cells with nuclei and organelles made from lipid membranes). Animals, plants and fungi are multicellular ogranisms composed of eukaryotic cells. Unicellular protists (protozoans and algae) are independently living eukaryotic cells. Modules #4, and #5 in this program treat the evolution of these great branches of life and show numerous examples of independently living prokaryotes and eukaryotes—a visual time capsule showing what life was like before the appearance of multicellular organisms.

Organic Molecules, the building blocks of life — Module #3

Module #3 teaches basic organic chemistry by illustrating carbon bonding patterns. It identifies the four types of biological macromolecules common to all living things and their building blocks: complex carbohydrates from sugar building blocks; fats (lipids) from fatty acid building blocks; proteins from amino acid building blocks; nucleic acids from nucleotide building blocks. It illustrates how these biological polymers are constructed from their building blocks through condensation reaction.



Starch polymer formed through condensation reactions.

Prokaryote Evolution and Diversity (module #4)
This module shows the variety of bacteria that can be found in organically rich water sources, a visual time capsule of what life may have looked like three billion years ago. All of these living bacteria can be seen in wet mount preparations using a light microscope, something every biology student should experience.

Prokaryotic cells, by definition, are cells without nuclei. Two major lines of prokaryotes split sometime before three billion years ago, the **Archaea** and the **Bacteria**. Archaeans are found in habitats that seem most unfriendly to life such as: deep in earth's crust breaking where they use inorganic compounds as an energy source; in hot springs and undersea hot vents where temperatures exceed 100 degrees Celsius; in animal intestines converting waste into methane gas; and in brine pools that would shrivel other cells.

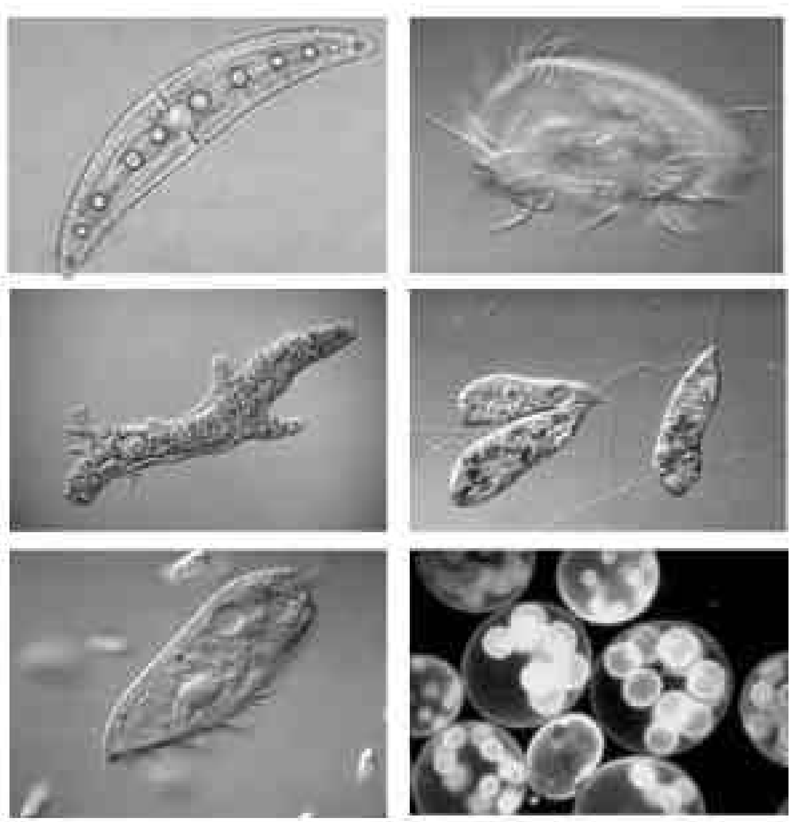
The **bacteria** shown in this section, all cultured from pond water, show the diversity of shapes and behaviors found in free-living bacteria. Bacteria break down organic material by secreting digestive enzymes into their surroundings. They absorb the digested products, using them for energy, growth and reproduction.

Cyanobacteria developed water-splitting photosynthesis sometime before two billion years ago, releasing the first free oxygen into the atmosphere—an event that changes the direction of life on Earth. The video shows filaments of cyanobacteria creeping over a surface (the microscope slide). In nature this slow creep can affords a cyanobacterium better exposure to light and nutrients.

Anabaena, *a common cyanobacteria that gives water a "swampy" taste.*

Independently-Living Eukaryotic Cells (module #5)
Eukaryotic cells, cells with nuclei, make up the bodies of plants, animals and fungi. The swarms of unicellular protists are, in themselves, eukaryotic cells. But exactly how did the cell nucleus originate? One theory is that a nucleus evolved in association with the loss of the cell wall, a loss that allowed the wall-less mutants to engulf other micro-organisms. This internalized the digestive process, subjecting the predatory cell's un-protected DNA to a whole new set of hazards. This situation set the stage for the selection of some form of membrane protected DNA.

Once in existence, a membrane enclosed nucleus proved a great advantage, and with the addition of cell organelles that carry out specific life functions, these early nucleated cells gave rise to swarms of microscopic eukaryotes. Looking at their descendants one can imagine what life was like in the period of time before multicellular organisms appeared.



A variety of *unicellular eukaryotes.*
Closterium (a green alga), Euplotes (a ciliate)
Amoeba, Peranema

Blepharisma (a ciliate), Volvox (a colonial alga)

Other video programs in the Visualizing Cell Processes series:

Cell Movement and Transport (15 minutes)

Modules: Behavior of the Plasma Membrane, Osmosis, Transport Proteins, Phagocytosis, Pinocytosis, Receptor Mediated Endocytosis, Golgi Function, Lysosomes and Digestion, Microtubules, Cilia, Actin and Myosin Motor Proteins

Photosynthesis and Cellular Respiration (15 minutes)

Photosynthesis Modules: Chloroplast Structure, Light Trapping by Chlorophyll, the Light Dependent Reactions of Photosynthesis, The Light Dependent Reactions of Photosynthesis

Respiration Modules: Glycolysis and Fermentation, Mitochondrion Structure, Aerobic Respiration, Krebs Cycle, Electron Transport Chain, ATP synthesis

DNA Replication and Cell Reproduction (15 minutes)

Modules: Mitosis: Chromosome Condensation, Mitosis: Stages, Cytokinesis, Meiosis, Nucleotide Structure and Bonding, Replication Enzymes, Replicating the Strands, The Twisting Problem, Proof Reading and Repair

The Genetic Code and Its Translation (15 minutes)

Modules: The Protein Nature of Life, Protein Structure, Transcription, Translation and Protein Synthesis, Gene Regulation in Prokaryotes, Classes of Eukaryote DNA, Exons and Introns, Mutations

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