FACT SHEET

NATIONAL INSTITUTES OF HEALTH

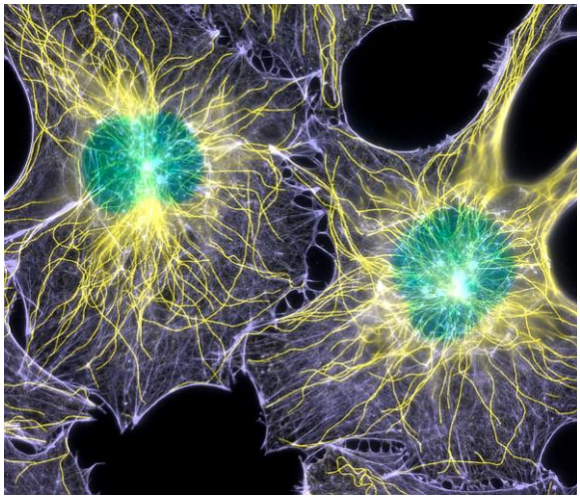
Strides in Sorting Out the Cell

Yesterday

- Scientists had described, isolated, and characterized organelles, the specialized substructures that carry out much of the cell's business. But they knew little about how organelles adapt to changes in the cell's environment or modify their function to meet the cell's constantly changing biochemical needs.
- Fats called lipids appeared to be important cellular components, but their functions remained unknown.
- Scientists debated the existence of channels in cell membranes that would allow molecules to flow into and out of cells.
- The cell's structural framework was just being explored. Myosin (a protein present in muscles that makes the muscle contract) was the only molecule known to move the cell or its organelles.

Today

- Scientists realize that cells are intricately structured and highly dynamic. The nature and molecular makeup of many internal features are well characterized.
- Advances in microscopy, especially real-time light microscopy, and molecular labeling allow scientists to track the complex movements of molecules and organelles within living cells.
- Researchers are investigating cellular transport systems that move organelles, chromosomes, and other molecular structures inside the cell. They have characterized three major families of molecular motors—myosins, kinesins, and dyneins—that push and pull cellular structures. The cables—microtubules, microfilaments, and intermediate filaments—along which these motors move are also under study.
- Scientist discovered drugs such as the anti-cancer agent paclitaxel (Taxol®) that work by disrupting dynamic processes within the cell. Paclitaxel blocks the disassembly of microtubules, which is necessary for cancer cells to divide or reproduce.
- Scientists understand many of the intricate details of how cells make proteins. After decades of work, NIH-supported researchers received a Nobel Prize for capturing high-resolution images of the ribosome, the cellular machine that assembles proteins. These images show how dozens of molecules work together in the processes that convert genetic information into functional proteins.



Actin (purple), microtubules (yellow), and nuclei (green) are labeled in these cells by immunofluorescence. This image won first place in the Nikon 2003 Small World photo competition. Source: Torsten Wittman, Scripps Research Institute

- Studies reveal that mistakes in how proteins fold into their active forms may underlie some diseases, such as Huntington's, Parkinson's, Alzheimer's, and Bovine Spongiform Encephalopathy (BSE), or mad cow disease.
- Research on lipids, especially cholesterol, and their roles in cellular transport and regulation led to the development of potent cholesterol-lowering drugs known as statins.
- Scientists know that membrane channels mediate many biological processes, including brain function, digestion, insulin release, hearing, sight, smell, and the beating of the heart. Thanks to new technologies,

researchers described the function of numerous membrane channels and captured high-resolution images of them. The result is a more detailed understanding of how these channels open and close and why flaws in the channels cause disease.

- To transport certain molecules to specific locations, cells use membrane-bounded compartments called vesicles. By studying model organisms, scientists have learned that vesicles are critical to the function of many cellular processes, including hormone secretion and transmission of nerve cell signals.
- Scientists learned that cellular housekeeping—quickly eliminating molecules that are defective or no longer needed—is vital to keeping cells healthy. They discovered biochemical pathways and organelles that cells use to get rid of unwanted proteins. Defects in these systems underlie several diseases, including Alzheimer's and Parkinson's and some cancers.
- Scientists have identified dozens of components of the extracellular matrix (ECM), the complex mix of molecules, minerals, and fluids that surround cells. The ECM provides cells with support, structure, and lubrication, allows cells to communicate with their environment and each other, plays an important role in embryonic development, and contributes to the overall texture and physical properties of tissues. ECM defects are linked to a variety of diseases, including atherosclerosis, brittle bone disease, kidney failure, certain types of deafness, and muscular dystrophy.

Tomorrow

- Cell biologists are developing computational models to study and simulate cellular processes. The models will help us understand how cells function as complex and adaptive machines.
- By integrating databases of genes, proteins, lipids, and other cellular components, investigators are teasing apart the thousands of molecular and genetic interactions occurring within our bodies and beginning to understand how some lead to disease.
- Scientists are designing new probes and other imaging tools not only to obtain ever-more-detailed snapshots of living cells, but also to manipulate cell movement—a process involved in development, the immune response, and cancer metastasis.
- With a deeper understanding of molecular travel within and between cells, scientists are developing improved drug delivery systems, including those that transport medicines to specific cell types or subcellular components. These new approaches will increase the effectiveness of medicines and reduce side-effects.
- Occasionally, errors in cell division can produce cells with too few or too many chromosomes and lead to cancer. Researchers are identifying the mechanisms that control cell division—and that help rein it in when the process goes awry.
- Progress in high-throughput protein structure determination techniques is bringing detailed views of an increasingly broad range of cellular proteins. These technical advances, supported in part through the NIH Protein Structure Initiative (http://www.nigms.nih.gov/Initiatives/PSI/), are helping researchers better understand the functions of thousands of biomedically important proteins.

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