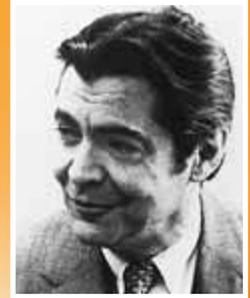


Science in Action

How Do Cells Secrete Proteins?

The invention of electron microscopes allowed biologists to see the detail of the tiny structures inside cells. But it was clever experimentation by George Palade that revealed how those tiny structures help a cell survive.



George Palade

HYPOTHESIS: Membranous Organelles Secrete Proteins

Six years after he graduated from medical school in Romania, George Palade began conducting research at the Rockefeller Institute for Medical Research in New York City. He studied the network of membranous organelles in cells of the guinea pig pancreas. This network included the rough endoplasmic reticulum (ER), the smooth ER, the Golgi apparatus, lysosomes, and secretory granules.

Palade knew about the structure of these organelles. He also knew that ribosomes on the rough ER were associated with making proteins. But what Palade and other scientists did not know was how the proteins were secreted from cells once they were made on the ribosomes. Palade suspected that the membranous organelles played a role.

METHODS: Track Proteins

Part of Palade's genius was inventing a way to make thin slices of tissue from a guinea pig's pancreas and keep the cells of the tissue alive. He also developed a way to track newly made proteins, a method called the *pulse-chase technique*. With this technique, Palade added "labeled" amino acids (made with radioactive atoms) to the pancreas cells for a fixed amount of time. This was the "pulse." The cells used the labeled amino acids and their own "unlabeled" amino acids (without radioactive atoms) to make proteins. Palade would then "chase" out any labeled amino acid that the cells had not used to build proteins by adding an excess of unlabeled amino acid.

RESULTS: Black Dots Move as Time Passes

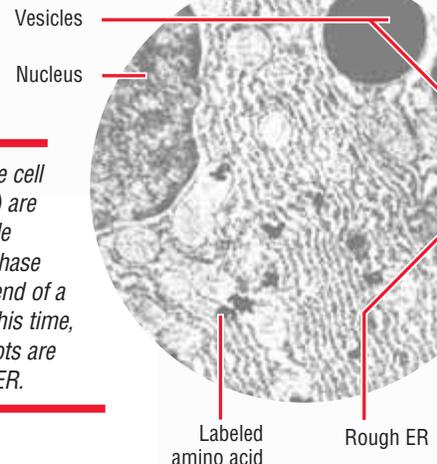
At first, the black dots that represented labeled amino acids were found in the rough ER. Photos taken at later time periods showed the black dots in vesicles close to smooth ER, then in smooth ER, then in the Golgi apparatus, and finally in vesicles close to the edge of the cell.

CONCLUSION: Secreted Proteins Follow a Specific Path

Palade concluded that secreted proteins move from the rough ER to the smooth ER in vesicles that are pinched off from the rough ER membrane. The proteins then move from the smooth ER to the Golgi apparatus (again, in vesicles). From the Golgi apparatus, the proteins move in vesicles to the edge of the cell. Finally, the vesicles fuse with the plasma membrane.

Further Experiments and a Nobel Prize

Palade published the work in 1964. In 1974, George Palade and two other researchers, Albert Claude and Christian De Duve, were awarded the Nobel Prize in medicine for their discoveries about the organization of the cell.



The black dots in the cell (labeled amino acid) are the black dots Palade found in his pulse-chase experiments at the end of a 3 minute pulse. At this time, most of the black dots are found in the rough ER.

REVIEW

1. What did the pulse-chase experiments allow Palade to observe?
2. Summarize the results of Palade's pulse-chase experiments.
3. **Critical Thinking** Was it important to use living tissue for the experiments?

