Cells contain several kinds of organelles. An organelle (ôrgəˈnel) is any of a number of organized or specialized structures inside a living cell. Ribosomes are among the most crucial organelles in cells. Here, we tell the story of how ribosomes were discovered.

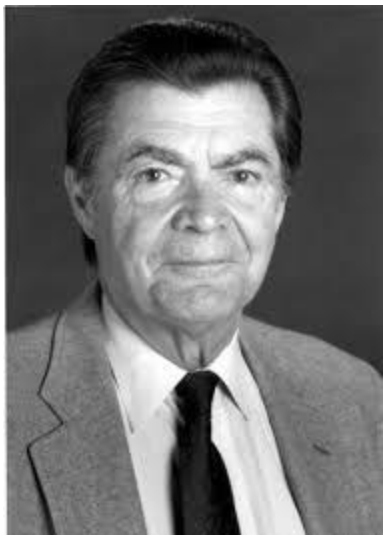
Organelles are important to you. For instance, from time to time, you will get sick. We usually blame sickness on some problem with our organs. Examples include lungs when we get the flu; or muscle when we have a bruise; or skin when we get sunburned. All disease begins with damage to one or more organelles within cells. The organelles allow cells to run smoothly when we are well.

Well now, you might ask, "Why should I care about how an organelle was discovered?" First, the discoveries of the various organelles tell a story about how scientists make discoveries. The story typically tells about how gaps in existing knowledge lead to new questions that motivate the scientist to develop a plan for testing.

Before we begin Dr. Palade's story, it helps to see how centuries of work on other organelles came before Palade. It all began with Robert Hooke, who invented a microscope that he used to magnify objects enough so that cells became visible. He worked with cork, which is actually dead tissue from the cork tree. What he saw were empty circles that he named "cells" because they reminded him of a prison cell that holds prisoners. But that raised a question that Hooke could not answer: "What did these cells contain when the plant was alive?"

Over the years, many other people with better equipment and ideas found the answers. To provide a little historical perspective, here is a list of major organelles and when they were discovered.

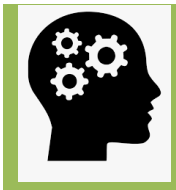
• 1665 cell membrane • 1676 vacuoles • 1833 nucleus • 1842 chromosomes • 1857 mitochondria	• 1903 cytoskeleton • 1945 endoplasmic reticulum • 1949 lysosomes • 1953 microtubules • 1955 ribosomes



Meet the Scientist

George Palade, 1912-2008

Dr. George Palade is considered by many to be the father of modern cell biology. He developed a unique way to separate the various organelles in cells. His method was valuable because it allowed organelles of a cell to be separated from each other with little damage. As a result, it was possible to learn the normal function of organelles. Dr. Palade also discovered ribosomes and their function and provided us with new information about other cell organelles. Because he could purify ribosomes without damage, he was able to discover their function in protein synthesis. This is turn helped other researchers find treatments for such diseases as cancer, anemia, bone marrow failure, and various genetic diseases.



Think About It!

In your notebook, state:

- **The procedure that Dr. Palade invented.**
- **The main organelle he studied.**
- **What this organelle does and why that is important to the cell**

George Palade was born in 1912 in Jassy (Iasi), the old capital of Moldavia, Romania. His father was a philosophy professor, and his mother was a teacher. In 1930, he started medical school in Romania at the University of Bucharest. During medical school he discovered that he was more interested in basic science than in medicine. After medical school, he started work on a PhD degree studying dolphin kidneys. He was trying to understand how the kidneys of marine mammals, such as dolphins, are able to get rid of all of the salt that is found in sea water. Little did he know that he was about to become a pioneer in cell biology.

During World War II, he served in the medical corps of the Romanian army. After the war, he came to the United States to continue his studies. In 1952, he became a citizen of the United States. While working for a few months in the biology laboratory of Robert Chambers at New York University, Palade met Dr. Albert Claude who was giving a seminar on his work with electron microscopy (EM). This technology magnified organelles enough to be seen. That stimulated Dr. Palade's interest in organelles. After the seminar, he chatted with Claude and somehow managed on the spot to get invited to work in Claude's lab at The Rockefeller Institute for Medical Research.

Think About It!

In your notebook, state:

- **How Dr. Palade came to switch his interest from medicine to organelles.**
- **Do you think your goals might change as you have new experiences?**

During the 1950s, Dr. Palade discovered ribosomes and their function. He also defined the fine structure of mitochondria (Figure 1).

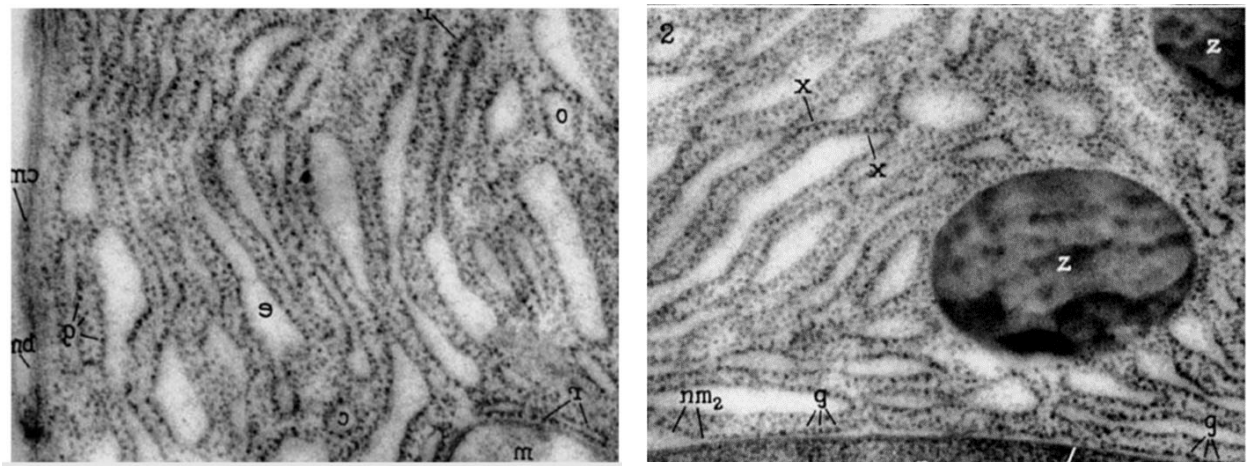


Figure 1. LEFT. One of the original EM pictures of ribosomes from a thin slice of rat pancreas. Ribosomes appear as little black dots. RIGHT: Electron micrograph in the vicinity of the nucleus in the same cell. Magnification = 73,000. From Palade et al. 1955.

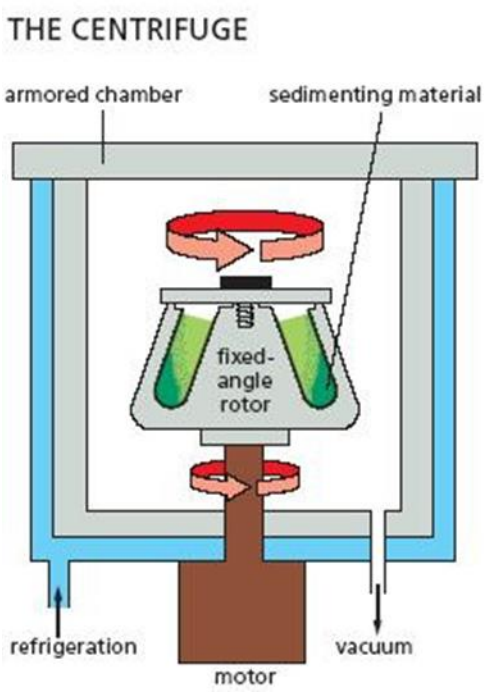


Figure 2. Using centrifuge

Dr. Palade was interested in more than just the structure of cell organelles. He also wanted to know their function. Dr. Palade needed a source of tissue that would provide living cells that he could study. He chose the guinea pig. He also needed a tissue that was always "busy" making secretions. For that, he chose the pancreas. The pancreas is very "busy" making gland secretions. Palade spent special effort studying ribosomes, because they contained a mixture of RNA (ribonucleic acid) and the proteins that they make.

At that time, the usual method to study the parts of a cell involved homogenizing (hə'mäjə¸nīz ing). This process breaks cells open to release their contents. Spinning (centrifuging) tissue samples at high speeds separates the organelles according to their density. The heavier particles are thrown toward the bottom of the test tube, while lighter-weight particles form the upper layers (Figure 2).

This process tore the organelles apart, and the resulting fractions were not very pure. Dr. Palade wanted to isolate cell organelles without damaging them so that he could analyze their biochemistry. He and two colleagues in Claude's lab modified the usual method of separating cell components by centrifuging homogenates in a sucrose medium. Scientists still use this method to extract specific molecules from plant or animal tissue.

The fractionation occurs in a tube prepared by layering progressively less dense sucrose solutions one upon one another without mixing. For example, the first layer of highest concentration is placed carefully in the bottom of a centrifuge tube. Then, in succession, layers of decreasing concentration are added carefully without mixing. Then cell homogenate is placed on top and centrifuged at very high speeds. Each cellular component begins to move down through the gradient and eventually reaches a position where the density of the organelle equals the density of the sucrose layer (Figure 3).

Think About It!

In your notebook, write a short answer for these questions:

- **What methods are required if all you want to do is see ribosomes?**
- **What methods are needed if you want to purify ribosomes and keep them intact so you can study their synthesis of proteins?**

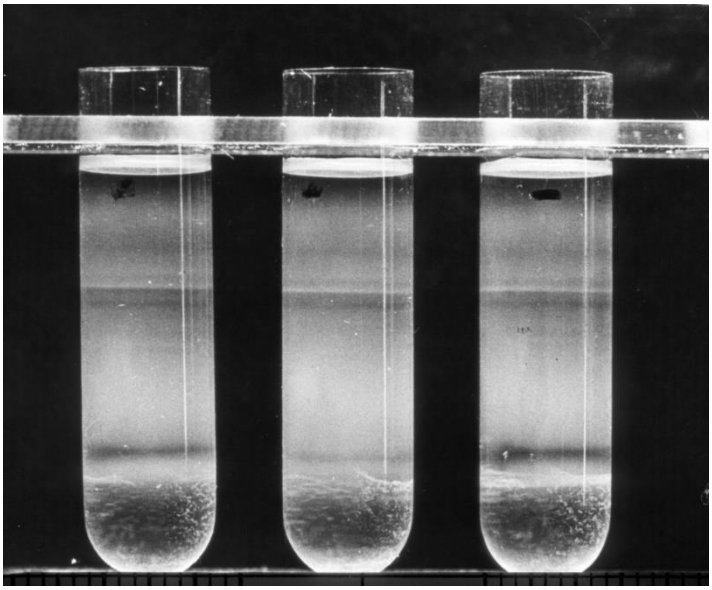


Figure 3. Appearance of bands of different organelles from guinea pig pancreas microsomes after being centrifuged in a sucrose gradient.

Dr. Palade continued to study the function of organelles, including the endoplasmic reticulum, the Golgi complex, the secretory granules, and the cell membrane. His love of Roman history and Latin, which is the basis of many words used in biology, were useful in helping him name many of the cell structures he identified.

Dr. Palade had a very long career and became a Dean at the University of California at San Diego School of Medicine.

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