An Analogue for the Cell

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ALTHOUGH ANALOGY sometimes leads to oversimplification, there are ways to construct analogies that make abstract concepts come alive with meaning while still offering a true picture of the operation of those concepts in nature. No analogy is completely accurate in describing a process or concept, but it should be accurate enough to allow for direct, obvious comparisons.

Many analogies cannot stand up to close analysis, and it is this breakdown under analysis that leads to oversimplification and misconceptions. *Webster's New World Dictionary* (1966) defines analysis as "A separating or breaking up of any whole into its parts so as to find out their nature, proportion, function, relationship, etc." The underlying concepts of biology require synthesis of a great many smaller ideas. Thus, a most effective teaching tool is the analogy that not only withstands analysis but encourages it.

Life Processes, Inc.

The concept of a cell as a collection of structures and processes, all of which lend to the functional characteristic we call life, is a difficult one to convey. An analogue for the cell must have components that are interrelated and function in a manner similar to the cell organelles. Fig. 1 is a diagram of a corporation composed of parts analogous to only the more important and obvious structures of cells. Each part of the corporation can be expanded when the analogous part in the cell is studied. Table 1 presents the analogies between the structures and functions of the corporation and the cell.

The powerhouse serves the same function in a corporation as the mitochondrion serves in a cell. Just as coal or oil is potential energy that must be converted into electricity, so glucose is a potential form of energy that must be converted into ATP. Both situations use a standard form of energy. Electricity runs most appliances and machinery so that whatever potential energy is delivered to the corporation, it is useless unless it is converted to electrical energy. Cells use ATP as a standard form of energy, and whatever potential energy is delivered to the cell, it must be converted to ATP. At this point a comparison of combustion (or burning) and biological oxidation may be made to bring about an explanation of why heat and light are released in the oxidation of coal, while a controlled and slow release of energy occurs in biological oxidation.

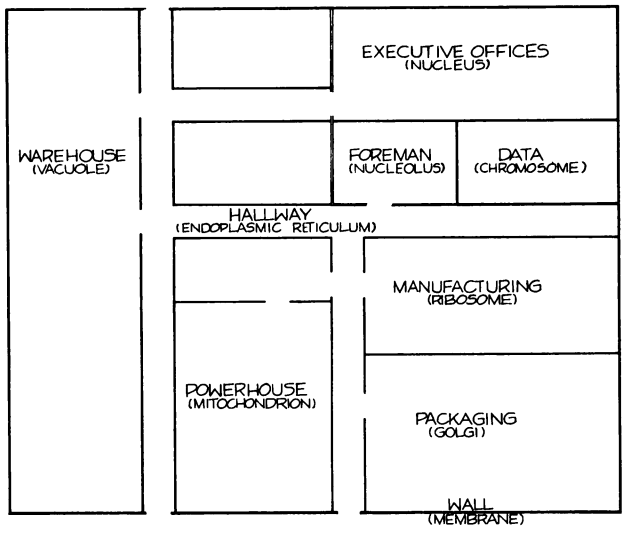

Fig. 1. Components of a corporation are analogous to structures in cells.

This is the essence of the difference between the powerhouse and the mitochondrion. Disparities are inevitable in any analogy but we have arrived at this one at a time when we are also considering the essence of the mitochondrion and wish to study the peculiarities that make it unique; namely, the role of enzymes, hydrogen accepting coenzymes, Krebs cycle, and the electron transport system. In other functions the analogy holds even to the point that both structures oxidize fuel, have the same breakdown products of CO_2 and H_2O, release the potential bond energy, and convert it to a more usable form. Many textbooks compare biological oxidation to burning, but it is not clear why. Here we can see the reason is that the two processes are of the same nature.

Other components of the corporation also lend themselves to an in-depth analysis. The executive offices control the corporation by virtue of the plans, blueprints, and technical data that are interpreted there and conveyed to the manufacturing center. The data in the cell is DNA and the foreman who does the leg work to convey data is analogous to RNA in the nucleolus of

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Table 1. Analogous corporate and cellular structures and their function.

Organelle	*Corporate structure*	*Function*
membrane	walls, fences	protection, regulation
endoplasmic reticulum	hallways	transport
nucleus	executive offices	control
nucleolus	foreman	messenger
chromosome	data banks	hereditary information
vacuole	warehouse	storage
ribosome	manufacturing	synthesis
mitochondrion	powerhouse	energy conversion
golgi	packing	modifying materials for export

the cell. The role of chromosomes as hereditary information and the role of RNA in the transfer of that information are important ideas that flow from this analogy.

Students have used this analogy to learn functions of cell organelles. It seems that a clear statement and example of the functions, and a view of the total relationship of these functions to the life of the cell, are important factors in reducing the degree of abstraction and therefore enhancing learning.

A real advantage of this kind of analogy is that after the detailed study of all the parts of the cell has been made, it may be more obvious why all these organelles are required to function to produce that set of conditions we call life. It can be pointed out that a corporation exists by virtue of the fact that it functions in a certain way. Without all of its components it would not function in the prescribed manner. So too, the cell requires certain essential structures in order to sustain life. The cell organelles may now be viewed as departments or components in charge of individual processes, all of which lend to the functioning of the larger process of life.

Further Views of Cells as Corporations

Some might argue that the analogy presented here may give an inaccurate picture of the role of organelles. Although the parts of the corporation are dependent on one another in order for the corporation to remain intact, the parts have a certain degree of independence in that they may have been in existence before the corporation itself existed. Some views of cells and their organelles are close to this idea. Margulis (1971) cites evidence pointing to the possibility that chloroplasts and mitochondria were once independent organisms. She refers to the origin of eukaryotic cells as a possible symbiosis of several cells without nuclei. Thomas (1974) has likened cells to societies and has expressed this same idea that cells may be aggregates of simpler forms which have lent themselves to a cell society.

Building an analogy that can be analyzed to this extent can offer a thread that can be maintained throughout an extended unit in cytology. This, along with a clear view of the functions of organelles and a view of the interrelationship of organelles, has made the development of this and other analytical analogies well worth the time and effort. The key to the success of these analogies is that they withstand (to a high degree) analysis, encourage it, and benefit by it.

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Photography . . .

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behavior in a pond (the mating behavior of ducks), and another did a study of city life, with emphasis on the more or less feral cats and dogs. In contrast, a couple of students prepared a photographic dissection of the fetal pig.

Botanical subjects have ranged from horse chestnut development to a description of plant tumors. A number of students have chosen to investigate the potentials of various technical aspects, such as copying book illustrations and transparencies, or photographing microscope preparations. One student cultivated the classroom use of mounted photographs and other illustrations. Macrophotography attracted some students, while others centered their work on the use of photomicrography and its use in teaching.

As indicated above, a few hints on operation are given at the beginning of the project to prevent serious mistakes, but no narrow technical criticism is offered of the final report, as would be expected in a conventional photography course; nor, in general, is such criticism sought by the students themselves. It would be aside from the main purpose of the photography project. This purpose can be fulfilled and attested to by the enthusiasm for a new tool for communication expressed by students—who, a few weeks before, did not even know how to put film in a camera, let alone know how to develop films and complete the process of expressing biological ideas in photographic terms.

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