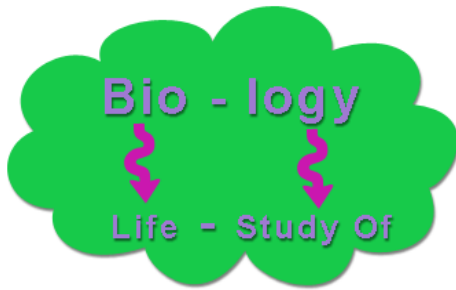


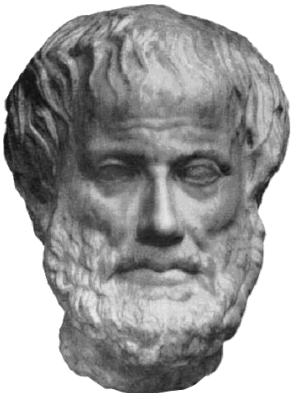
## Cell Theory



- Biology & Cell Theory
- Biology is the "Study of Life".
- Living things can feed, metabolize, grow, die reproduce, respond & move.

"Metabolize"? Build or break-down big molecules - specifically our 4 polymers.

### What is Life and how does Life happen?

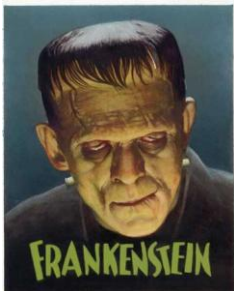


Until recently, this question was quite confusing! Many agreed with an ancient Greek philosopher named Aristotle who was convinced no real boundary existed between "living" and "non-living". Non-living matter could give rise to living things because our universe possesses some vital life force or soul, "anima", which could "animate" non-living matter. In Aristotle's view the universe as a whole had its own soul. In modern terms the universe could be considered some giant [fractal](#) and we are all but elements therein. Various mystical traditions hold similar ideas.



Is there something magical, spiritual or supernatural to life? Early scientists (beholden to Aristotle) reckoned; yes.

Maybe there is a natural force - present in air perhaps - after all, we need air to live! This unknown was not called "x" as in algebra. In Biology, it was called "vital force" or "vital principle". That explains why the ancient Hebrews did not believe that life began at conception. According to the Hebrew Testament, life ("ensoulment") commenced with the baby's first breath. Connection with vital principle somehow meant connection with air! Meanwhile, "may-the-force-be-with-you" movies were ultimately inspired by Aristotelian traditions. (Go figure!)

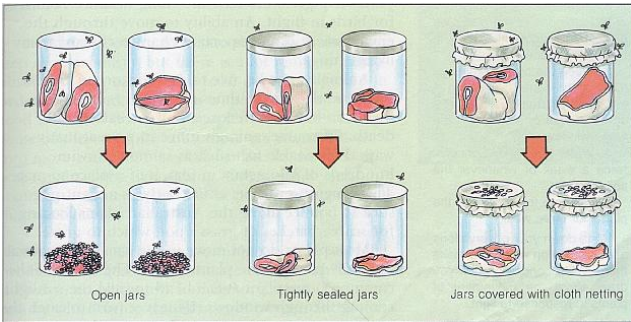


Later scientists were also beholden to Aristotle and accepted Aristotelian beliefs that sea slime or mud can spontaneously give rise to sea creatures and that decaying meat spontaneously gives rise to maggots. Scientists were also beholden to ancient traditions that air was obviously important to animation! Medical Science's job was to figure out how to harness this vital force to cure disease and undo death. Remember the novel Frankenstein was considered credible in its day. [Link](#)

The belief that non-living matter can give rise to living things is called "[spontaneous generation](#)"; (aka "[abiogenesis](#)" and "[heterogenesis](#)" - they all mean the same thing)

Tom Mueller  
- RHS

A series of experiments eventually disproved "spontaneous generation". Fransico Redi demonstrated in 1668 that Aristotle was wrong about maggots. Maggots did not arise spontaneously, but from eggs laid by adult flies.

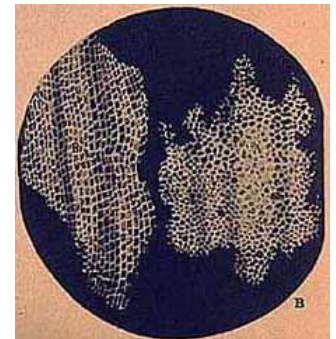


Click : [Another link.](#)

Meat covered with cloth preventing contact with flies remained free of maggots, while meat in contact with flies developed maggots.



At about the same time, an English scientist, Robert Hooke, discovered "cells" in a piece of cork, which he examined under his primitive compound microscope. Actually, Hooke only saw cell walls because the cork cells are dead and lacked cytoplasm. Hooke drew these structures and coined the word "Cell".



The word cell is derived from the Latin word '*cellula*' which means small compartment, like those in monasteries that monks or priests would inhabit.

Ten years later Anton van Leeuwenhoek (1632-1723), a Dutch businessman used his own (single lens) monocular microscopes and was the first person to observe bacteria, protozoa and swimming sperm (...don't ask!). Leeuwenhoek is known to have made over 500 "microscopes," of which fewer than ten have survived to the present day.

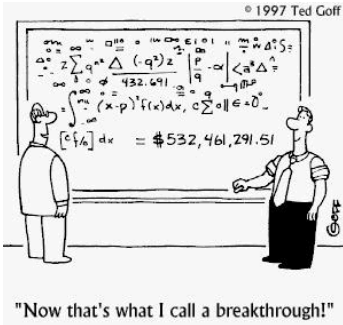


Leeuwenhoek's instruments were simply powerful magnifying glasses, not compound microscopes. Leeuwenhoek's skill at grinding lenses, together with his naturally superior eyesight and dexterity enabled him to see specimens at over 200 times magnification; better than any competitors of the day. Van Leeuwenhoek created quite a sensation, when he discovered an entire microscopic world could live on a speck of dust or drop of water. Maybe our own world was someone else's speck of dust! The imagination just boggles!

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Not much happened for the next 100 years, because Leeuwenhoek took to the grave, his secret lens-grinding techniques. It took a while before compound microscopes became powerful enough to visualize cells in any detail. In 1833, Brown observed and described the first organelle, the nucleus. (He also discovered [Brownian motion](#), the incessant agitation of minute suspended particles).



**Brief aside:** The randomness of "Brownian Motion" was mathematically modeled by Albert Einstein. Einstein's "Brownian" [formulas](#) were recently exploited by so-called "Quants", those math wizards hired by investment banks to invent financial products (such as derivatives based on sub-prime mortgages) and to design computer programs in order "to game" our global financial system. Essentially, banks were able to use clients' money to bet against their own clients in order to generate bigger bank profits. These "Quants" almost destroyed Wall St. and the entire international banking system by mistakenly assuming that Einstein's formulas (premised on randomness) also could apply in non-random scenarios; such as panic-fraught bank-runs. (I only wish I were making this up!)

Now here is an interesting question: Who first came up with the idea that all living things consist of cells? That would depend on whose side you are cheering for; the French or the Germans. Some suggest it was Lorenz Oken, a German "Naturphilosoph" and microscopist, who postulated the first version of "cell theory" in 1805. Other historians suggest Henri Dutrochet the French physician, botanist and physiologist deserves that honor. Other names were also put forward. In science, talk (even for a great idea) is "cheap". Without scientific research and data to back you up; you have no claim to fame!

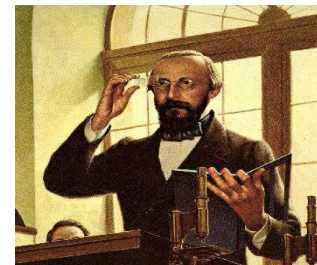
Credit now goes to:



Matthias Schleiden



Theodor Schwann



Rudolf Virchow

Schleiden studied plants. He freely acknowledged his debt to Brown for first describing the nucleus. Schleiden came to believe that the plant nucleus is really the most important cell structure constituting the original structure from which next generation of cells developed. Schleiden called it the cytoblast. Think [stacking Russian dolls](#) ("Cell pregnancy"? OK, he got that one wrong.)

One evening in 1838, Schwann and Schleiden were discussing the apparent coincidental similarities of animal and plant cells, as examined under the microscope. The two scientists abandoned their after-dinner coffees and rushed to Schwann's lab to check out his animal cell slides. Schwann immediately published a book on animal and plant cells, a monograph giving little credit to anyone else's contribution, even Schleiden's. (Schwann was a real jerk!)

Schwann summarized "his" observations as three conclusions about ALL cells:

- 1) The cell is the unit of structure, physiology, and organization in living things.
- 2) The cell retains a dual existence as a distinct entity and a building block in the construction of organisms.
- 3) Cells form by free-cell formation, like the formation of crystals in solution, in the presence of other cells. (There is that spontaneous generation, again!)

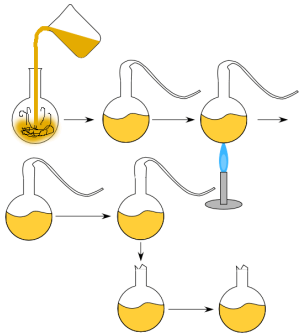
We know today that the first two tenets are correct, but the third is clearly wrong.



The correct interpretation of cell formation by division was finally promoted by others and formally enunciated in Rudolph Virchow's powerful dictum (and Latin pun), "Omnis cellula e cellula"...

"All cells only arise from pre-existing cells" (...i.e cell division!)

The problem was Virchow couldn't prove it! How can you "prove" something never happens? (Maybe, you just are not looking hard enough!)



Many people still believed that spontaneous generation could at least generate primitive or microscopic life (if not complicated life, like maggots). Early experiments indicated meat broths would quickly swarm with microscopic life. Meat broths that were boiled never gave rise to microbes. Maybe the boiling destroyed "vital principle" present in air.

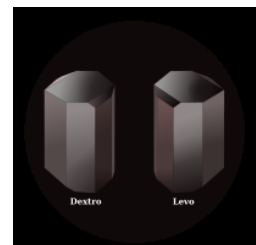


Pasteur's famous experiments proved that sterilized broth exposed to air via swan necks and with no chance of contamination - never generated microscopic life. Pasteur concluded that microbes only occur by contamination. Pasteur then figured out how to sterilize wine ("Pasteurization"). Only as a later afterthought, was milk also "pasteurized". French scientists always had a firm grip on priorities!

[Link](#)

Science always proceeds in fits and starts. Pasteur believed that all life processes (including fermentation) were special reactions that could only occur in living organisms. Living cells produced pure optical enantiomers. Scientists in the lab could only synthesize "racemic" mixtures. According to Pasteur, those marvelous macromolecules made by a cell could never be made in a test-tube; and for some good, albeit obscure reason.

There just had to be something special, maybe even supernatural, to life. Pasteur reckoned that living things (the cells) still contained some mysterious "vital force". (There's that Aristotle again!) [Pasteur was wrong for all the right reasons!](#) Even though Pasteur first understood the "homochirality problem", Pasteur did not know about enzymes which generate products with precisely uniform 3-Dimensional shapes.



Tom Mueller - RHS

So where does this leave us? The modern tenets of the Cell Theory include:

1. All known living things are made up of cells. (There is a boundary between life and non-life)
2. The cell is structural & functional unit of all living things. (When living things feed themselves, metabolize, grow, reproduce, respond and move, die - cells alone are doing the job.)
3. All cells come from pre-existing cells by division. (Spontaneous Generation does not occur).
4. Cells contain hereditary information which is passed from cell to cell during cell division. (Again no magic or supernatural forces, no spontaneous generation neither)
5. All cells are basically the same in chemical composition. (No vital forces required)
6. All energy flow (metabolism & biochemistry) of life occurs within cells. (Again, no vital forces)

So after all and done, does Aristotle get tossed into the dustbin of history?! Not so fast!



The modern Gaia hypothesis is an ecological hypothesis that proposes that all living and non-living parts of the Earth' biosphere together are a complex interacting system that can be thought of as a single organism.

We have come full circle and Aristotle is vindicated after all!  
You will see more on all that in Environmental Science Unit.  
(Keeners can click on the picture for a neat hyperlink)

James Lovelock should not get exclusive credit for the Gaia hypothesis. Lynn Margulis also deserves some praise! [Link](#) Next we learn about Cells' structures.

A grateful tip of the hat goes to University of Miami Professor Charles Mallery's great [site](#)

## Questions:

What is a controlled experiment?

What is a manipulated variable?

Describe the experiment that Redi designed. What was the result?

Describe the experiment that Pasteur designed. What was the result?

Explain (with reference to Aristotle) why Pasteur's experiment needed to be in contact with air.

What did the experiments of Redi and Pasteur prove?

What Greek philosopher believed in "abiogenesis"?

The first scientist to work with a compound (i.e. two-lens) microscope:

What is the origin of the term "cell"?

What are microbes?

Who discovered them?

Name two scientists who may first have suggested an early version of cell theory:

Refer to your text as well as your notes:

Describe the contributions of each scientist to resolving “abiogenesis”:

Redi	Needham	Spallanzani	Pasteur

Describe the contributions of each scientist to Cell Theory:

Brown	Schleiden	Schwann	Virchow

Describe their contributions, each scientist got something wrong. Describe the error for each:

Schleiden	Schwann	Pasteur

“Omnis cellula e cellula” means \_\_\_\_\_

In 1828, Friedrich Wohler prepared urea (basic component of urine) “...without needing a kidney, whether of man or dog...” Did this result contradict Pasteur’s later ideas? (Hint – Pasteur was a smart man!)

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The 6 points of modern cell theory:

- 1
- 2
- 3
- 4
- 5
- 6

What is the Gaia Hypothesis?