

The Microscope and Cell Theory

With ideas about inheritance

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The Microscope

- The telescope expanded consciousness of the vastness of the universe.
- The microscope brought awareness of an existence below ordinary consciousness.
- Kinds of microscopes:
 - Compound (2 lenses)
 - Simple (one lens)

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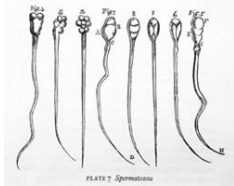
Anton van Leeuwenhoek

- 1632-1723
- Very secretive worker
- Ground his own lenses
- Did detailed drawings of microorganisms enlarged up to 2000 diameters



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Anton van Leeuwenhoek, 2



- Very high level of skill required to use his (simple) microscopes.
- Discovered spermatozoa, and published drawings of them.

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Robert Hooke



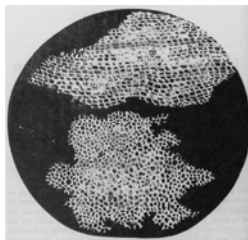
- 1635-1703
- Newton's arch enemy
- Used a compound microscope, with very poor resolution.

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Cells

- Hooke examined a slice of cork under his microscope.
- Saw a lattice work.
 - a honeycomb formation
- Called them *cells*.

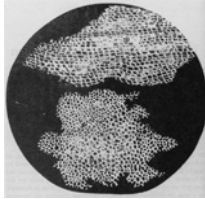


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Cells, 2

- Cells of plants form permanent walls that exist after the cells die (and disappear)
- Hooke's work drew attention to the *walls* of cells.



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Early Compound Microscopes

- Like a telescope in reverse
- Could magnify about 30 times
 - A magnifying glass can magnify about 10 times

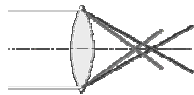


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Chromatic Aberration

- Why compound microscopes were so poor:
 - Different wavelengths of light are bent unequally by glass
- Newton showed that nothing could be done about it.
- He invented the *reflecting telescope* to cope with it.
 - At right, Newton's reflecting telescope.

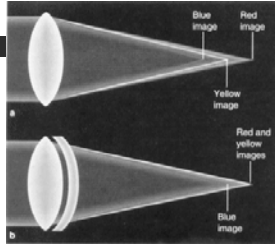


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The Achromatic Compound Microscope

- Invented in 1820s.
- By 1830 in general use – leading to much more research.
- Chromatic aberration can be avoided by making lenses of components of more than one kind of glass.

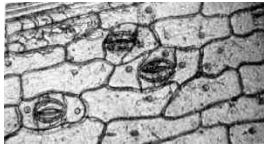


Above: The chromatic aberration problem. Below: the solution by adding another kind of glass to the lens.

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The Cell Nucleus



- Discovered by Robert Brown in 1833, in plant cells
- Brown noted that the nucleus was a regular part of plant cells
- Brown's discovery focused attention on the *interior* (that is, the living) part of the cell

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Cell Theory – Plant Cells



- M. J. Schleiden
 - Ex-lawyer
 - Had doctorates in medicine and philosophy
 - Became a botanist
- Held that all plant tissues were composed of nucleated cells.
- Plants are aggregates of plant cells
 - Announced in his work: *Contributions to Phytogenesis*, 1838

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Cell Theory – Animal Cells



- Theodor Schwann
 - Zoologist
 - Stimulated by Schleiden to look at animal tissue more closely.
- Concluded that *all living things, plants and animals develop from the formation of cells.*
- Expressed in his work: *Microscopic Researches on the Conformity in Structure and Growth Between Animals and Plants*, 1839

Metabolism

- Schwann coined the term *metabolism* to refer to the chemical processes within the cell.
- Metabolism is “respiratory combustion” in the cells.

The battle against vitalism

- Vitalism is the philosophical position that living beings are fundamentally different from dead matter
 - Possessing a *vital force* or an *animal spirit*, for example.
 - This is antithetical to the mechanist view of science that dominated in the post-Newtonian world.
 - The alternative is *reductionism*.

Reductionism

- Schleiden and Schwann promoted a *mechanistic* view of biology
 - All life was really chemistry, physics, and mathematics.
 - Life arose as nuclei formed cells.
 - Cells formed from chemical reactions at a cellular level.
- This is **reductionism**.
 - Reductionism is consistent with mechanist science.

Cellular Pathology

- Rudolf Virchow
 - Pathologist, anthropologist, politician.
 - Applied cell theory to medicine
 - *Cellular Pathology*, 1858.
- Virchow studied diseased cells under a microscope.
 - Associated certain abnormalities in cells with specific diseases.



Omnis cellula e cellula

- “All cells come from (pre-existing) cells”
 - This was Virchow’s doctrine
- Cells are the universal units of living matter
 - Virchow changed the emphasis in medicine away from the whole organism toward the concept of the cell as an intermediate level of organization
- Biology found its *unit* for laboratory research: The Cell.

How does life arise?

- How do species reproduce themselves from generation to generation?
- Some of the main issues:
 - Does life arise from nothing?
 - Does life come from non-life?
 - What about spontaneous generation?
 - What is the role of mating?

Something from nothing?

- At some point in the birth process, a new living thing comes into being.
- Is life created from nothing, or was it always there all along?
 - If so, where and in what form?
 - If not, is life beyond the reach of cause and effect?

Life from non-life

- Does life arise from matter that was not alive?
- Or is life something apart from the matter out of which bodies are made?

Spontaneous generation?

- Sometimes new living things arise where there were no obvious parents about?
 - For example, parasites, fungi.
 - Even mice were thought to arise spontaneously in vases of grain.



The role of mating

- What about the mating process? What does it accomplish?
 - If life arises after sexual mating, what actually goes on that causes life?
 - Is the living matter, or force, or cause, or whatever, something stored:
 - entirely in the male,
 - entirely in the female,
 - or is it some kind of blend of seminal fluids from each parent?

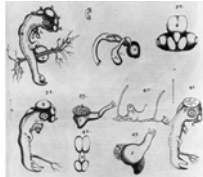
Preformation Theories

- Assume that life was there all along.
- If so, where?
 - Answer, somewhere in the parents.
 - Which parent?
 - And then, what's the other parent for?

Ovists

- Believed that all of the essence of life resides in the female, the mother.
- The role of the father is merely to stimulate the growth of the latent fetus with his sperm, or, for plants, pollen.

Ovists, 2



- Marcello Malpighi (1628-1694)—prominent ovist
 - Did extensive studies of chick embryos with a magnifying glass and discovered the stages of the development process from fertilization to birth.

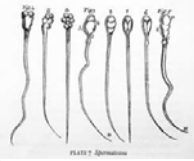
Spermists

- Believed all of the structure of life resides in the male and is transmitted to the female.
- The *homunculus*.
 - A supposed miniature form of life that existed fully formed in the male sperm.
 - The female's role is to provide the environment for growth.



Spermists, 2

- This view was given strong support by the invention of the microscope and Anton von Leeuwenhoek's drawings of spermatozoa swimming madly in his specimen.
- Note: After von Leeuwenhoek's work, semen was no longer seen as just some nutritive fluid.



Where the logic of Preformationism leads



- If all life pre-exists in the parents, there must be a finite amount of life and therefore all life must come to an end.
- Jan Swammerdam (1637-1680), an ovist, took the view that life was preformed in the female ovum.

Where the logic of Preformationism leads, 2

- But many ovum would also contain the preformed life of the later generations too.
 - This can be traced back to the first woman (Eve), who must have had within her the life form of every human that ever would be. Eggs nested within eggs, etc.
- **Thus life must end when all of these eggs are finally played out** and the last generation of females are born without the potential to give life.



Possible views of the origin of living things

- Preformationism
 - It's been there all along (since creation) and just develops.
- Epigenesis
 - Life arises anew out of non-living ingredients by some process of intervention that remains to be explained.
 - It is consistent with either vitalism or reductionism, depending on the process assumed.
- Pangenesis
 - Bits from the body of the parent(s) collect in the genitals and are passed on in sexual intercourse.

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Explanatory concepts and models

- Vitalism
 - A life force exists, different from the forces of inanimate nature.
- Reductionism
 - Life is just complex chemistry and physics.
- Continuous
 - Living stuff is smooth and continuous, with imperceptible gradations.
- Discrete (or particulate)
 - There are small indivisible units of heredity

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Vitalism – Idealism



- A leading vitalist in the 19th century was Karl Nägeli (1817-1891)
 - a botanist and cytologist
 - studied philosophy under Hegel
- Nägeli proposed that there were 2 kinds of substances in every living thing:
 - a *tropoplasm*, which builds the bodily structure and dies when the organism dies.
 - an *idioplasm*, which directs the form that the organism takes.

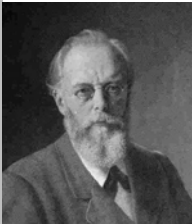
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Nägeli's *Idioplasm*

- The *Idioplasm*
 - Was immortal
 - Too fine to be detected by instruments
 - In reproduction, the idioplasm of both parents mingle in the fertilized ovum
 - Evolution was seen as the expression of the "automatic perfecting process" of the idioplasm. (a sort of Lamarckian inheritance of acquired characteristics).
 - For example: monkeys will evolve into humans some day.

Reductionism – Mechanism



- A leading reductionist in the 19th century was the zoologist, August Weismann (1834-1914)
 - Revised and transformed Nägeli's view with a mechanist-reductionist interpretation.
- Proposed two kinds of cells:
 - Soma cells – which were the general cells of bodies – forming their structure, and having nothing to do with reproduction.
 - Germ cells (or *germ plasm*) – which were the cells that carry inheritance.

Weismann's *Germ plasm*

- The *Germ plasm*
 - Was immortal – because cells produce by cell division.
 - Body cells derive their structure from the germ cells (not vice versa).
 - "A chicken is nature's way of making another egg."
 - Evolution is carried on in the germ plasm.
 - And crucially: the germ plasm is *particulate*.

Chromosomes

- Cells were identified as essential building blocks of life early in the 19th century, but cells, especially animal cells, are very hard to see under a microscope.
- Late in the 19th century, the German chemical industry invented of some dyes that could be used on microscopic specimens.

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Chromosomes, 2



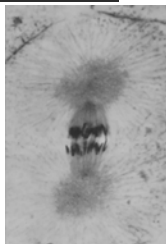
- Certain long string-like structures that appeared in the nuclei of cells took stains very well. They were given the name *chromosomes* (i.e., colour bodies) in 1888.

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Chromosomes and Cell Division

- In the process of cell division, the chromosomes were seen to duplicate themselves exactly, then separate before moving apart to opposite ends of the nucleus.
- The daughter cells each contained a complete set of chromosomes, just like the parent.
- Weismann said that the germ plasm must be carried by the chromosomes.

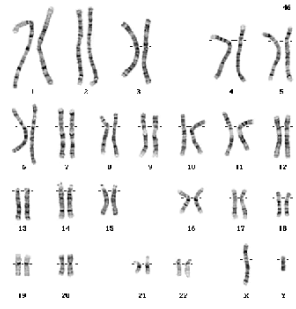


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Human chromosomes

- Human beings were found to have 46 chromosomes, coming in 23 pairs.
- The last pair determine the sex of the person.
 - 2 "X" chromosomes make a woman.
 - 1 "X" and 1 "Y" chromosome make a man.



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