



Scientists in Germany, Contemporaries of Mendel

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Nineteenth Century Europe

- Politically active period
- Medicine and science emerging from the “dark ages”
- Technology and science expanding
- Selected sites of scientific activity for this paper are Berlin, Vienna, and Brno



Educational Reforms

- Prussia reformed its educational system in the early 1800s
- Paved the way for talented young men to rise through the social system by their own merit
- Powerful family influence and affluence could be overcome



19th Century Science

- Science expanded enormously
- New fields emerged: anthropology, cell biology, organic chemistry, psychology, geology, evolution
- Science became a paid profession
- Teaching of science and scientific research began at universities



Scientific Societies Developed

- Scientists were experimenting and inventing
- Scientists began communicating
- First communicated within countries; then became international
- Methods of travel improved
- Societies began holding congresses
- Publication of papers important

Germany

- Science was strongly organized
- Berlin University founded in 1809 by Wilhelm von Humboldt, director of Prussian Department of Education
- Alexander von Humboldt, his brother, was a naturalist and explorer



Naturphilosophie

- Philosophy of nature was questioned
- **Vitalism** says that living things have a unique property
- This was being replaced by new ideas



Mechanism: *Kraft und Stoff*

- Force and matter became the tenet of the new philosophy
- Physical laws can explain life functions



Science and Technology

- Electricity and magnetism being examined
- Thermodynamics is a new field
- Study of waves: light and sound

Experimentation

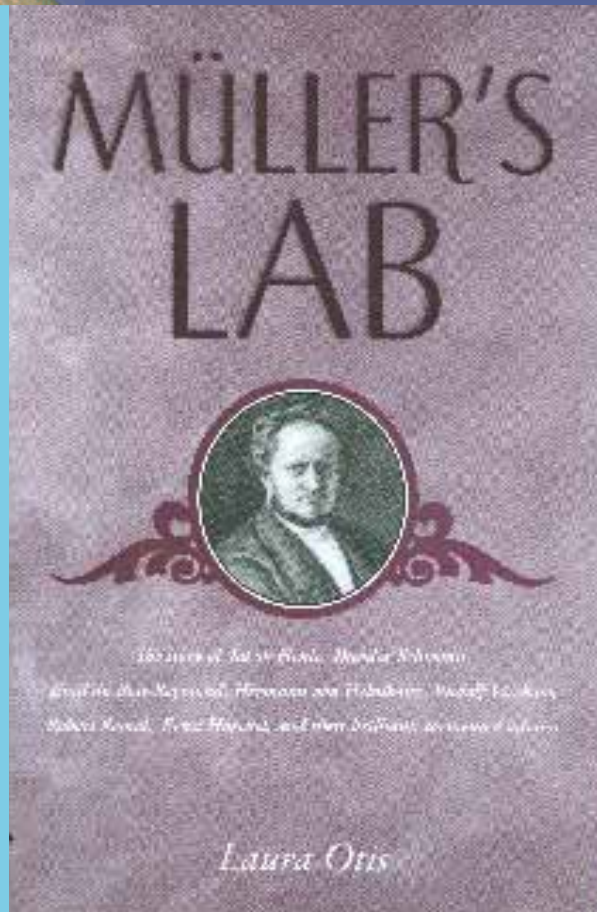
- Began using devices and instruments to test the properties of living matter
- Galvanometers measured intensity of electrical current
- Achromatic microscope eliminated chromatic aberration along edges of structures

A photograph of laboratory glassware is positioned on the left side of the slide. It includes a large, clear glass bottle with a stopper, a smaller brown glass bottle with a stopper, and a small, rectangular, yellowish container with a red label. The background of the slide is a gradient of blue and purple.

The Laboratory

- Often not a designated space
- Students worked in the places they lived
- No electricity, refrigeration, or indoor plumbing
- Devices had to be improvised by the experimenter or constructed by a local machinist

My Inspiration



Author: Laura Otis

- BS (Molecular Biophysics & Biochemistry)
- MA (Neuroscience)
- PhD (Comparative Literature)

Published by Oxford University Press, 2007

Dr. Otis awarded a MacArthur Fellowship for creativity



Müller's Students

- Johannes Müller joined the faculty of Berlin University in 1833
- Many students were taught by Müller and many became his assistants and helpers
- Seven in particular are described in Otis' book because of their scientific significance
- You might recognize many eponyms among these individuals



Johannes Müller

- Born in 1801 near Bonn in western Germany
- Family was Roman Catholic; father a cobbler
- Johannes feared poverty and respected his Prussian mentors
- Gave him a conservative outlook

Müller Educated in Bonn



- Won post as lecturer there
- Became professor of anatomy & physiology at Berlin University in 1833
- Henle and Schwann moved from Bonn to Berlin with him



Talented Physiologist

- Demonstrated spinal roots: dorsal are sensory and ventral are motor
- Encouraged students toward experimentation and microscopy
- Müller became involved in developing an extensive anatomical museum collection
- Believed that living organisms possessed a unique force = vitalism



Year of Political Upheaval - 1848

- Müller, as university rector, tried to maintain order
- Found himself caught between his respect for the king and his radical students
- Never fully recovered from the horrors

Jakob Henle (1809-1885)



- Born to Jewish family that converted to Christianity
- Moved to Berlin to complete education
- Shared Müller's passion for putting things in order



Henle as Microscopist

- Acquired new achromatic microscope
- Compound microscope combines the magnifying power of several weak lenses
- Wrote *Studies in Pathology* in 1840
- Said some diseases are caused by microscopic living organisms
- Lead to development of germ theory by other scientists

Theodor Schwann (1810-1882)



- Born to wealthy Catholic family
- Quiet and serious student
- A contrast to Henle who accompanied his work on cadavers with delightful humor and sparkling wit



Theodor Schwann

- Studied mathematics of muscle contraction
- Used microscope but preferred systematic experiments
- Studied protein digestion and found something more than acid was required; something else may predispose digestive products to decomposition without itself decomposing (an enzyme?)



Schwann and Schleiden

- Schwann had dinner with Schleiden
- Schleiden described the important role of plant cell nucleus
- Schwann took him to his lab and showed him nuclei in notochord cells
- Marks the birth of the “Cell Theory”

Emil du Bois-Reymond



- Born in 1818 to wealthy, upper-class Protestant family
- Mother French Huguenot
- Regarded himself superior to most Germans



Emil du Bois-Reymond

- Built his own more sensitive galvanometer
- Demonstrated electrical activity in frog's muscle
- Like Müller, demanded that a good physiological experiment yield “the same certain and unambiguous phenomena in any place, at any time, under the same conditions”



Emil du Bois-Reymond

- Took Müller's position at Berlin University upon Müller's death in 1858
- Said, "My only grief is that poor Müller was to die for it, when he was so kindly disposed in my behalf."

Hermann von Helmholtz



- Born 1821 to Protestant family
- Family educated, but not wealthy
- Thought physical laws could explain life functions



Law of Conservation of Force

- von Helmholtz declared that when energy changes form, none is lost or created
- Also determined the velocity of nerve impulses
- If velocity of nerve impulses is measurable and constant, then they must be electrical and/or chemical

Rudolf Virchow (1821-1902)



- Born from humble origins in a rural area
- Studied medicine because he wished to practice it
- Hoped his microscopic observations would assist in the treatment of patients



Virchow's Science & Politics

- Felt that science and politics were inseparable
- Blamed a typhus epidemic on failed government policies
- Hoped to reform Prussia through improved education and public health
- Champion of free speech

Robert Remak (1815-1865)



- Born to poor Jewish family in what is now Poland
- Family had strong interest in politics
- His religion proved to be a decided disadvantage



Remak and Microscopy

- Observed neuronal structure, cell reproduction, and embryological development
- Showed that myelinated nerves are not hollow but filled with substance
- Accepted term “axis cylinder” suggested by Purkinje for threads they both observed



Remak and Embryology

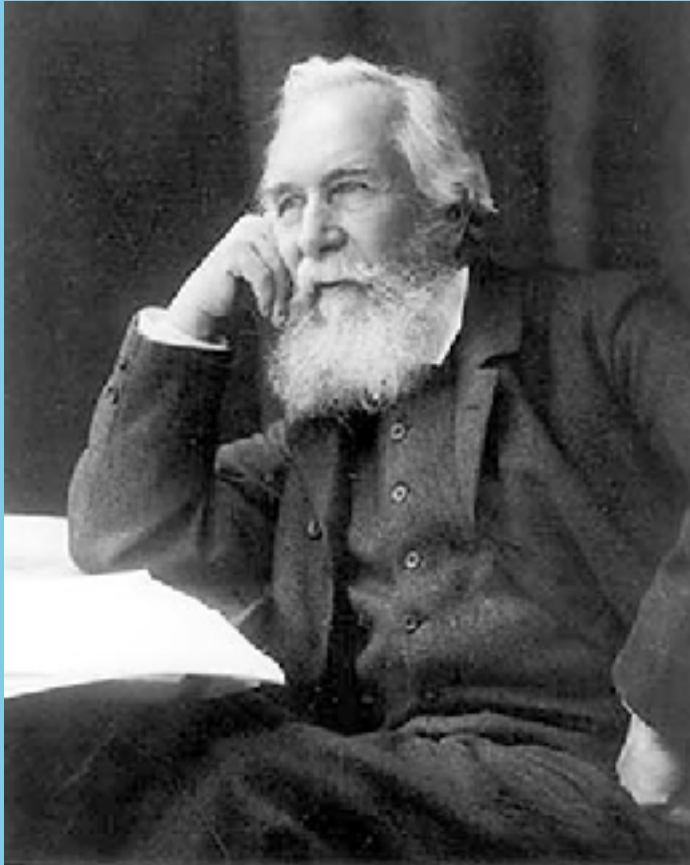
- Remak is best known for his embryological studies
- Identified the three embryonic germ layers
- Determined which organs develop from each germ layer



Remak and Virchow

- Remak observed cell division in embryos
- Virchow studied cells from pathological viewpoint
- Both said, “*omnis cellula e cellula*,” all cells come from preexisting cells
- Remak never forgave Virchow for taking credit and not acknowledging Remak’s contribution

Ernst Haeckel



- Born in 1834 to middle-class Protestant family
- Family valued culture and education
- Critical of medicine as an “art”
- Wanted demonstrable rules and theories

Haeckel Combined Science & Art

- Talented in both
- Made collections of invertebrates, especially radiolaria
- Learned to look through microscope with left eye and draw with right eye

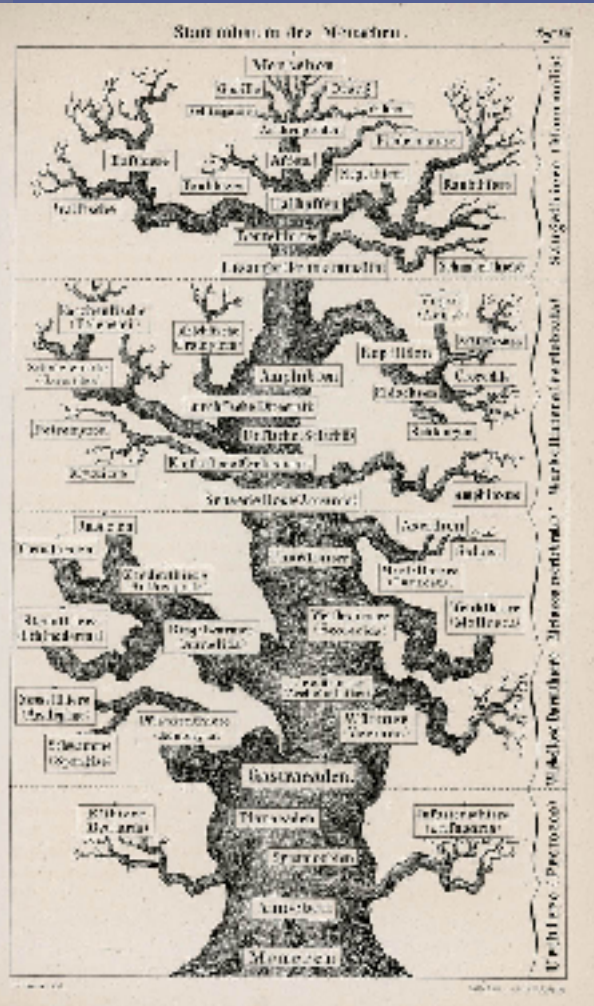




Haeckel and Evolution

- Developed own phylogenetic approach to comparative anatomy
- Believed animals related through common lines of descent
- Read the German translation of *The Origin of Species* in 1859 and fully embraced Darwin's idea of living things evolving from common ancestors

Phylogenetic Tree



- Developed and drawn by Haeckel
- Darwin's theory allowed Haeckel to reorder his knowledge – modern species evolved from ancestral ones

What About Mendel?



- Joined Augustinian Monastery in Brno in 1843
- Sent to Vienna University for further education
- Vienna also a center of science scholarship



Mendel in Vienna

- Studied plant physiology under Franz Unger
- Christian Doppler was his professor for experimental physics
- Influenced by Andreas Baumgartner who emphasized importance of studying nature through experiments theoretically supported by mathematical models



Mendel's Method of Research

- Founded on the identification of significant variables, isolating their effects, measuring these meticulously, and eventually subjecting the resulting data to mathematical analysis: the scientific method as Mendel was taught in Vienna



Mendel's Experimentation

- His experiments with peas were systematically recorded over a period of eight years from 1856 to 1863
- Paper with his results published in 1866
- Rediscovery in 1900 revealed Mendel's genius and foresight



Educational Reform

- Students could rise by their own merit
- Not necessary to have a wealthy or powerful family
- Need intelligence and diligence to be recognized by a teacher
- A mentor for encouragement is crucial



How Will We Remember?

To learn more about the history of science and the individuals that contributed so much visit:

- The Mendelianum at the Augustinian Monastery in Brno
- The Berlin Museum of Medical History at the Charité

Mendelianum at the Augustinian Monastery in Brno



Berlin Museum of Medical History at the Charité



Step into History

