

Microbiology: What is it?

- Study of organisms who are too small to be seen without a microscope.
- Study of small organisms or microorganisms. NOT just Bacteria!
- Study of single celled organisms. The original cell biology!
- Categories & subjects based on the type of organisms:

- (1) Viruses – Virology (acellular)
- (2a) Bacteria – Bacteriology (e.g. Prokaryotes)
- (2b) Archea – Archealogy? (already taken)
- (3) Fungi – Mycology
- (4) Algae – Phycology
- (5) Protozoa – Protozoology

WHAT IS A MICROORGANISM?

“There is no simple answer to this question. The word ‘microorganism’ is not the name of a group of related organisms, as are the words ‘plants’ or ‘invertebrates’ or ‘fish’. The use of the word does, however, indicate that there is something *special* about small organisms; we use no special word to denote large organisms or medium-sized ones.

- Siström (1969)

Reasons to study Microbiology:

- (1) Bacteria are part of us! E. coli lives in our gut and produces essential vitamins (e.g. K).
- (2) Infectivity & Pathogenicity; MO's have the ability to cause disease in compromised &/or healthy hosts.
- (3) MO's in the environment; Bioremediation or use of MO's to breakdown waste compounds like oil, pesticides, etc. Mineral cycling of elements like N, S, Fe, etc.
- (4) Applied Microbiology or use in agriculture and industry.
- (5) Understand basic biological processes: Evolution, Ecology, Genetics, etc.

WHY STUDY MICROBIOLOGY?

“The role of the infinitely small is infinitely large.”

- Louis Pasteur (1862)

WE ARE NOT ALONE!

“We are outnumbered. The average human contains about 10 trillion cells. On that average human are about 10 times as many microorganisms, or 100 trillion cells...As long as they stay in balance and where they belong, [they] do us no harm...In fact, many of them provide some important services to us. [But] most are opportunists, who if given the opportunity of increasing growth or invading new territory, will cause infection.”

- Sullivan (1989)

Natural Microbial Populations

- Typical soil: $\sim 10^9$ MO's per gram
- Typical fresh water: $\sim 10^6$ to 10^7 MO's per ml
- Open Ocean: $\sim 10^5$ to 10^6 MO's per ml
- Complexity (soil): 10^4 to 10^5 different prokaryote-sized genomes per gram

Prokaryotes: The unseen majority

Whitman et al., 1998 PNAS

Table 5. Number and biomass of prokaryotes in the world

Environment	No. of prokaryotic cells, $\times 10^{28}$	Pg of C in prokaryotes*
Aquatic habitats	12	2.2
Oceanic subsurface	355	303
Soil	26	26
Terrestrial subsurface	25-250	22-215
Total	415-640	353-546

*Calculated as described in the text.

Pg = Petagram or 10^{15} grams

Prokaryotes: The unseen majority

Whitman et al., 1998 PNAS

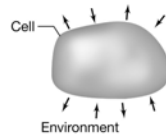
	Total C (Pg)	Total N (Pg)	Total P (Pg)
Plants:	560	12-20	1-2
Prokaryotes:	350-550	70-120	7-12

Take Home Message: Prokaryotes contain 60 to 100% the cellular carbon of all plants along with $\sim 10x$ the N and P of plants!

Hallmarks of cellular life

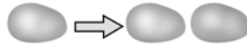
1. Metabolism

Uptake of chemicals from the environment, their transformation within the cell, and elimination of wastes into the environment. The cell is thus an open system.



2. Reproduction (growth)

Chemicals from the environment are turned into new cells under the direction of preexisting cells.



Hallmarks of cellular life

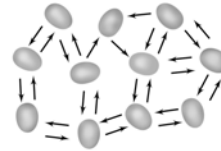
3. Differentiation

Formation of a new cell structure such as a spore, usually as part of a cellular life cycle.



4. Communication

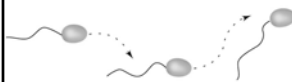
Cells communicate or interact primarily by means of chemicals that are released or taken up.



Hallmarks of cellular life

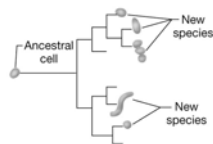
5. Movement

Living organisms are often capable of self-propulsion.

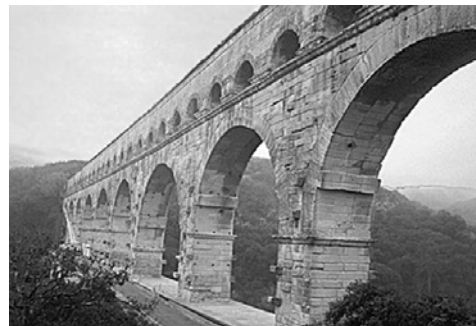


6. Evolution

Cells evolve to display new biological properties. Phylogenetic trees show the evolutionary relationships between cells.



Roman Aqueduct: Sanitation Age



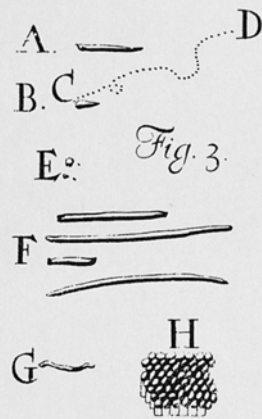
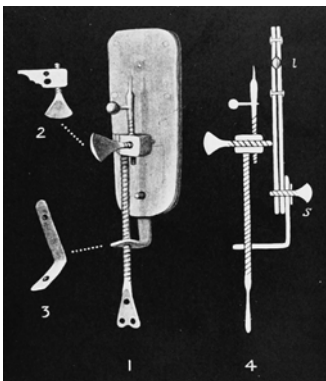
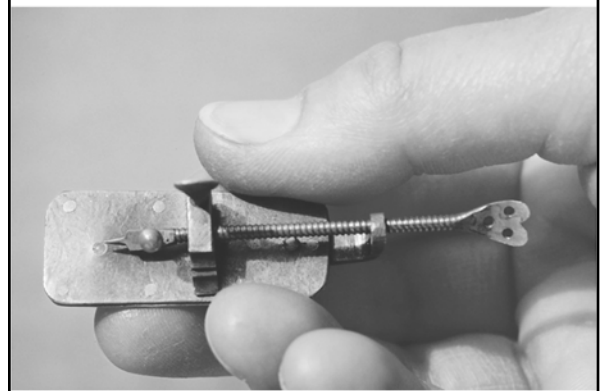
Robert Hooke's microscope

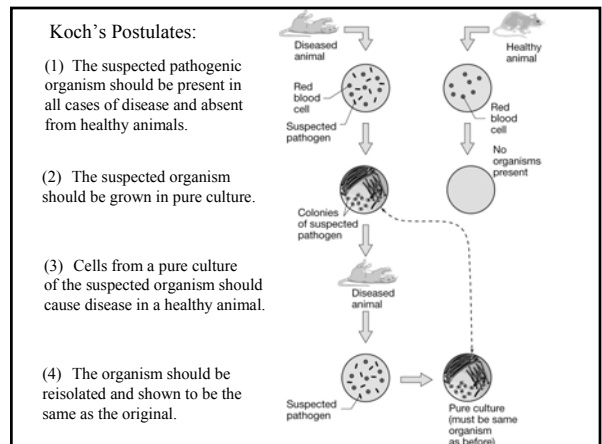
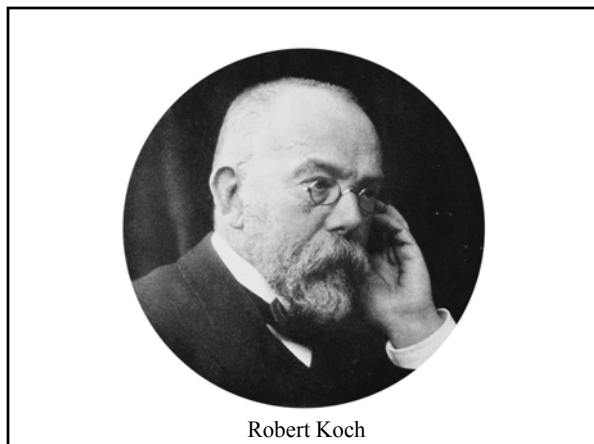
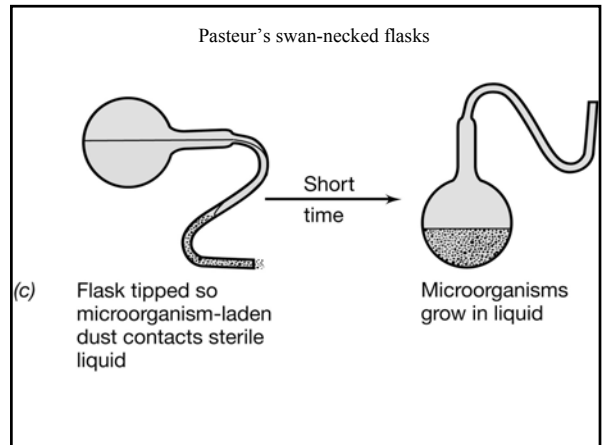
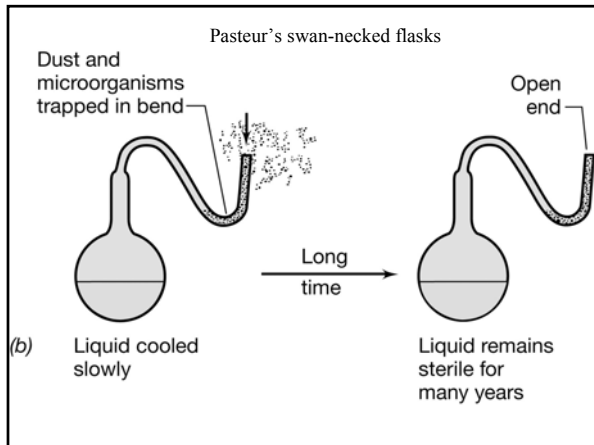
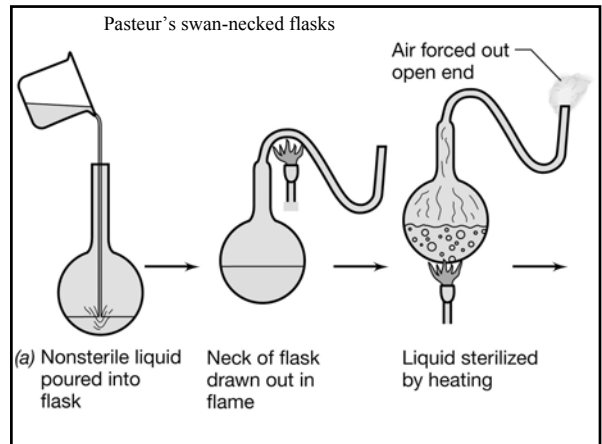
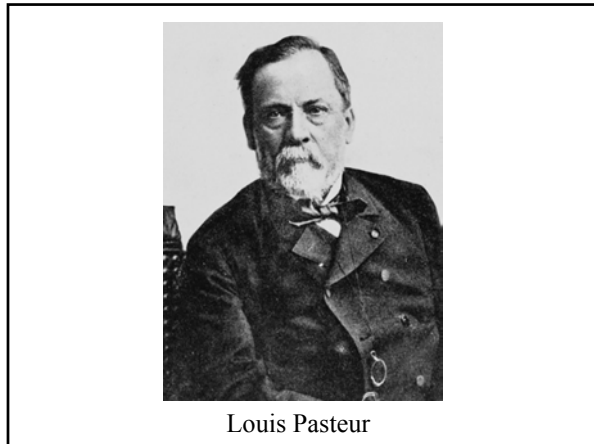


Able to see Mold



ANTONIUS A LEEUWENHOEK
Regis Secretarius Leuvenensis
membrum.





Archaeoglobus fulgidus Genome

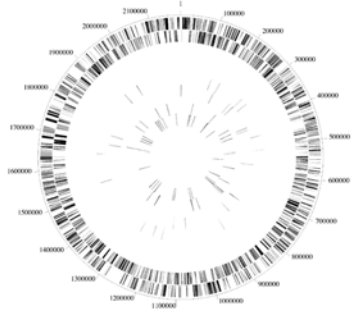
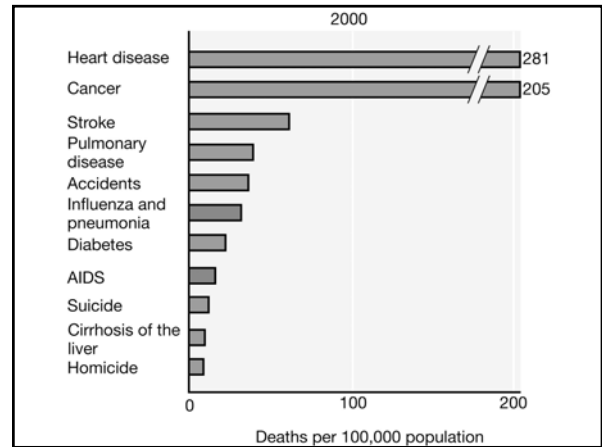
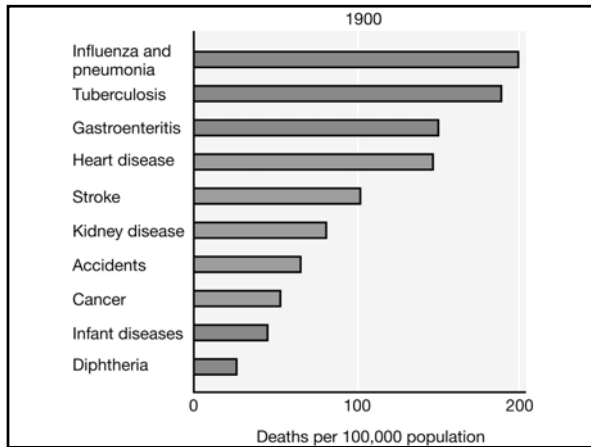


Figure Legend:
A circular representation of the *A. fulgidus* genome illustrating the location of each predicted coding region as well as selected features of the genome. Outer concentric circle: predicted coding regions on the + strand classified as to role. Second concentric circle: predicted coding regions on the - strand. Third and fourth concentric circles: IS elements (red) and repeats (blue) on the + and - strand, respectively. Fifth and sixth concentric circles: tRNAs (blue), rRNAs (red) and small stable RNAs (green) on the + and - strand, respectively.

Comparative death rates over the last century in terms of top 10 lists

Key:
Green are non-microbial diseases,
Red are microbial diseases.



Proteorhodopsin phototrophy in the ocean

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Proteorhodopsin¹, a retinal-containing integral membrane protein that functions as a light-driven proton pump, was discovered in the genome of an uncultivated marine bacterium; however, the prevalence, expression and genetic variability of this protein in native marine microbial populations remain unknown. Here we report that photoactive proteorhodopsin is present in oceanic surface waters. We also provide evidence of an extensive family of globally distributed proteorhodopsin variants. The protein pigments comprising this rhodopsin family seem to be spectrally tuned to different habitats—absorbing light at different wavelengths in accordance with light available in the environment. Together, our data suggest that proteorhodopsin-based phototrophy is a globally significant oceanic microbial process.

From Nature, 2001

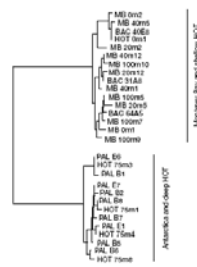


Figure 2. Phylogenetic analysis of the inferred amino acid sequence of diverse proteorhodopsin genes. Clustal analysis of 225 positions was used to determine the best fit neighbor joining tree. The Prochlorococcus group of the Woese/Chao group and the 10.0 Genomics Cluster Group, Modicum, Woese et al. H. salinarum bacteriorhodopsin was used as an outgroup, and is not shown. Scale bar represents number of substitutions per site. Bold names indicate the proteorhodopsins that were specifically characterized in this study.

Take Home Messages:

May the real “bacteriorhodopsin” Please stand up!

Major new way to make ATP in the ocean.

Two distinct “flavors” or evolutionary trajectories.