

BIOL 240: General Microbiology

Spring 2020 Rm. 23-203 Mon., Jan. 13

Dr. Nathan Staples (Ph.D., UCSB)

1. **Part I:** Basics of Microbes, molecules and cells.
– Midterm 1 = **Wed., 2/19.**
 2. **Part I, II:** Microbial Metabolism & Growth; Control.
– Midterm 2 = **Mon., 3/16.**
 3. **Part II, III, IV:** Microbial Genetics, Biotechnology, & Microbial Diversity; Host-Microbe Interactions.
– Midterm 3 = **Mon., 4/20.**
 4. **Part IV:** Immunity, Microbial Diseases, Evt. Micro.
- FINAL EXAM** (1/3 cumulative): ****Mon., May 18, 11:10am-1:40pm**

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Syllabus: “Fine Print”

- ❖ **PROFESSOR’s INFORMATION:** Lecture: **11:10AM - 12:35PM**
- ❖ **Dr. Staples’s Office/Open Lab hours (23-333, 23-355):** Mon./Wed. **9:05-9:35 AM** and **2-3 PM.** Tues./Thur.: **12:45-2 PM, or by appointment!!** ☺
staplesn@smccd.edu, (650) 306-3251
- ❖ **Website:** <http://accounts.smccd.edu/staplesn/biol240/index.htm> ****
 - 1) “Pre-Lecture” slides available online each evening before class!!
 - 2) **STUDY GUIDES & Lesson Objectives (Due WED!!)**, syllabus, lectures, etc.
 - 3) **Quizzes ONLINE** every 2 weeks (posted Tue., due WED.!) <https://smccd.instructure.com/>
 - 4) Thur. morning/afternoon **REVIEW SESSIONS** week before EACH Exam!!
- ❖ ***** STUDENTS:** are expected to keep-up with ALL the reading for each day’s lecture. Also, be sure to complete any Study questions and Discussion problems before the next class. (& www.masteringmicrobiology.com).
- ❖ **Bring large, 11” x 8.5” BLUE BOOKS on this Wednesday!!**
- ❖ ***** 0.5-1 Hour By Arrangement is *expected* WEEKLY!:** for extra lab practice (**open lab!!**), group work/reports, lab notebooks, study guides, and Learning Center study groups/review sessions. During **office hrs/open labs.**
 - You will be tested upon your **knowledge** gained in this class, but **MOSTLY** your level of **comprehension** and ability to **apply** the major concepts (So, do NOT just memorize facts and details!!).
 - **Diligence will be your key to success in this class.** I want you ALL to do well and have FUN learning about the fascinating & mysterious world of microbiology!!

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“Fine Print” cont’d

- **** EXAMS: 3 MT, 1 Final (partially cumulative); (& 7 Quizzes)**
 - For every exam, bring **a pencil** (#2 or HB lead), **a blank “RED” scantron answer sheet**** (100 questions per side, “a-e”), & a rested and ready mind!!
- **There will be NO MAKE-UP or RESCHEDULING of Exams** (except for *documented emergencies*), so check your schedule NOW and PLAN appropriately!!
 - If you predict or have any problems, talk to Dr. Staples IMMEDIATELY!!!
- You must satisfactorily **pass BOTH the Lecture and Lab (at least 60% in each)** to pass this course with a “C” or better!!!
- ❖ **Cheating in any form will NOT be tolerated, and disciplinary action will be severely enforced by College Administration!!**
- ❖ **ATTENDANCE: is MANDATORY For both LECTURE and LAB.**
 - You WILL FAIL the course if you do not attend at least 90% of class hours.

- **LAB: (AB: 9:35AM!! AA: 12:45PM)** Lab Manual is at the bookstore (Staples, 12th Ed., Aug. 2018).
 - 1) ***** Read Introduction, TYPE Pre-Lab (for WHOLE week EACH Experiment, each MON!!!), and prepare for the next exercise BEFORE Monday’s Lab!!**
 - 2) **Composition/bound notebook (sewn spine)** is preferred for lab observations, data and conclusions. Graph/quad paper preferred. (NO spiral-bound notebooks or binders).
 - 3) **ALWAYS bring GOGGLES (safety glasses) and closed-toed shoes. Lab Coats are optional.**

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** Study Tips (6) **

1. **Read the Textbook** thoroughly, BEFORE CLASS.
 - If you do this, you WILL do well in this course.
 - If not, #2-6 won’t help much. **[Be IN CLASS ON TIME!!!]**
 - **Open your textbook TONIGHT!!**
 - **Answer Questions, Do Problems!! ... PRACTICE!**
2. Spend significant time **understanding figures** illustrating concepts or processes.
3. **Take good notes** and **annotate** notes from the textbook. **Record lectures!** (*Slides are NOT a substitute for active note-taking!!*)
4. Condense notes into **summary sheet of main concepts** (see **Study Guides!!**) with examples or diagrams, &
5. **Draw-out structures and processes** for yourself!
 - *Flow-charts, Diagrams, Outlines, TABLES to organize information.*
6. Form a **study group!!** Share ideas & understanding. **Explain concepts and quiz each other! TALK about it!**
 - **DRAW!! DRAW!! DRAW!! DRAW!! DRAW!!**

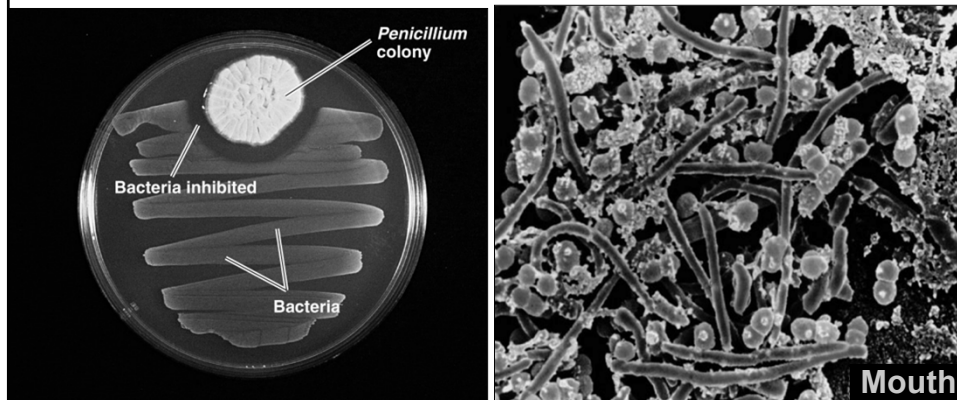
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Why do you want to learn MicroBiology?

- Find a very **PERSONAL** motivation for learning!!!
 - “I study Biology, because I want to understand more about the living world around me and that is a part of me.”
- There is an immense **DIVERSITY** of life on earth, and an immense diversity of life-sustaining processes.....
- Perhaps the most interesting and manipulable organisms are **MICRObes**, especially bacteria.
 - Most of the life processes in microbes are directly applicable to the biology of humans and other animals!!
 - Cellular life holds much **UNITY** between all living things!
- ❖ Entering into the Microscopic World and exploring its mysteries is a great adventure!! It can teach me enormous amounts of information about myself and the world I live in.

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Chapter 1 The Microbial World & You



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OBJECTIVES:

Students should be able to:

1. Name and describe the 7 major “groups” that include microorganisms.
2. Diagram and describe how **Louis Pasteur** proved how life truly arises.
3. Describe the work and significance of the discoveries of **van Leeuwenhoek, Pasteur, Jenner, Koch and Fleming.**
4. Diagram & describe **Robert Koch’s postulates**, and explain their significance to modern medicine and infectious disease.
5. **Ch. 2:** Describe the 6 “**Elements of Life**”, their relative **electron affinities** and bonding properties, and their roles in biomolecules.
6. Describe how the **Octet Rule** affects chemical bonding, and distinguish between the relative strengths of the **3 main chemical bonds** formed in biomolecules.

❖ **These questions are your HOMEWORK between classes!!!**

➤ **DUE (and/or Study Guide questions) NEXT WED. at the start of Lab!!**

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Microbes in Our Lives

- **Microorganisms** are organisms that are too small to be seen with the unaided eye.
- **“Germ”** refers to a rapidly growing cell.

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Activities of Microorganisms:

1. Decompose organic waste.
2. Are producers in the ecosystem by photosynthesis.
3. Produce industrial chemicals such as ethyl alcohol and acetone.
4. Produce fermented foods such as vinegar, cheese, and bread.

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Microorganisms:

Cell Types:

“Prokaryotes”:

- Bacteria, archaea.

Eukaryotes:

= us! Animals, plants, fungi, protists (algae, protozoa)

Acellular microbes:

- Viruses, viroids, prions.

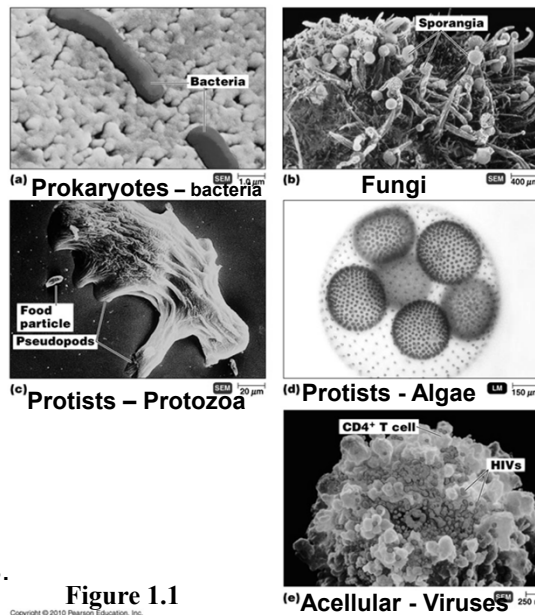


Figure 1.1

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Microorganisms:

- Produce products used in manufacturing (e.g., cellulase) and medical treatment (e.g., insulin)
- ***A few are pathogenic = disease-causing***

Knowledge of microorganisms:

- Allows humans to
 - Prevent food spoilage
 - Prevent disease occurrence
- Led to aseptic techniques to prevent contamination in medicine and in microbiology laboratories.

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1.1) Naming & Classifying Microorganisms

- **Carolus Linnaeus** (1735) established the system of scientific nomenclature.
- Each organism has two names: the **Genus** and **specific epithet**.

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Scientific names

- Are italicized or underlined.
 - **Genus** is CAPITALIZED
 - ***specific epithet*** is lower case.
- Are “*Latinized*” and used worldwide.
- May be descriptive, or honor a scientist.
- For Example:
 - ***Staphylococcus aureus***
 - Describes the clustered arrangement of the cells (staphylo-) and the golden color of the colonies.
 - ***Escherichia coli***
 - Honors the discoverer, Theodor Escherich, and describes the bacterium’s habitat: the large intestine or colon.

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Classification of Microorganisms

❖ Three Domains: (6 Kingdoms)

1. Bacteria
2. Archaea
3. Eukarya
 - a. *Protists*
 - b. *Fungi*
 - c. *Plants*
 - d. *Animals*

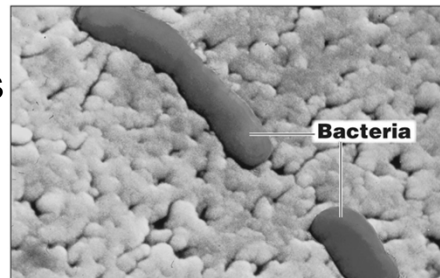
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Classification of Microbes:

A. Bacteria (Eubacteria)

1. Prokaryotes

2. Peptidoglycan cell walls
3. Divide by Binary fission
4. For energy:
 - use organic chemicals, inorganic chemicals, or photosynthesis



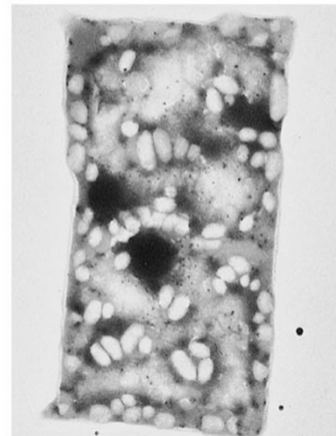
(a) SEM 1.0 μm
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Haemophilus influenzae

Figure 1.1a

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B. Archaea

1. Prokaryotic
2. Lack peptidoglycan
3. Live in extreme environments
- Include:
 - *Methanogens*
 - “*Extremophiles*”:
 - Extreme halophiles
 - Extreme thermophiles



TEM 0.5 μm

Figure 4.5b

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C. Fungi

1. **Eukaryotes**
 2. **Chitin** cell walls
 3. Use organic chemicals for energy
- **Molds and mushrooms** are multicellular
 - consisting of masses of **mycelia**,
 - which are composed of filaments called **hyphae**
 - **Yeasts** are unicellular



Figure 1.1b

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D. Protozoa (Protista)

1. Eukaryotes
2. Absorb or ingest organic chemicals
3. May be motile via pseudopods, cilia, or flagella

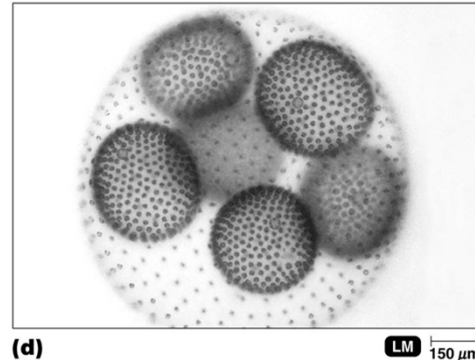
**Amoeba**

Figure 1.1c

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E. Algae (Protista)

1. Eukaryotes
2. Cellulose cell walls
3. Use photosynthesis for energy
4. Produce molecular oxygen and organic compounds



Volvox

Figure 1.1d

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F. Multicellular Animal Parasites

1. Eukaryote
 2. Multicellular animals
 3. Parasitic flatworms and round worms are called **Helminths**.
- Microscopic stages in life cycles.

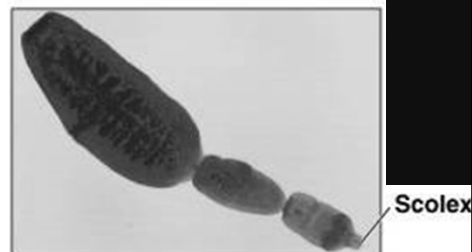
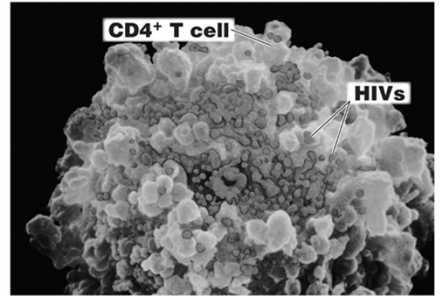


Figure 12.28

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G. Viruses (acellular!)

- **Acellular**
- Consist of DNA *or* RNA core.
- Core is surrounded by a protein coat.
- Coat may be enclosed in a lipid envelope.
- **Obligate Parasites (Intracellular)** = replicate only when they are inside of a living host cell.



(e)

SEM 250 nm

HIV on WBC

Figure 1.1e

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1.2) A Brief History of Microbiology

- Ancestors of bacteria were the first life on Earth.
- The first microbes were observed in 1673.
– **Van Leeuwenhoek**

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A. The First Observations

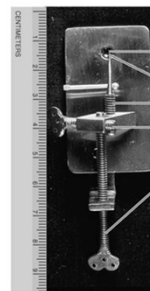
- In 1665, Robert Hooke reported that living things were composed of “little boxes” or “cells”.
 - Matthias Schleiden (botanist), Theodor Schwann (physiologist) -- 1830's-1840's.....
- In 1858, Rudolf Virchow said cells only arise from preexisting cells.
- ❖ Cell Theory: All living things are composed of cells, and all cells come from preexisting cells.

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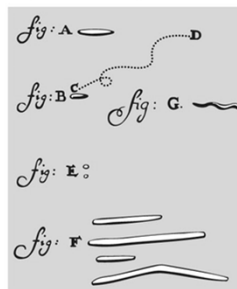
The First Observations



(a) Van Leeuwenhoek using his microscope



(b) Microscope replica



(c) Drawings of bacteria

- 1673-1723 (studies), Antoni van Leeuwenhoek:
 - described live microorganisms (“*animalcules*”)
 - observed in teeth scrapings, rain water, and peppercorn infusions

Figure 1.2

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B. The Debate Over Spontaneous Generation

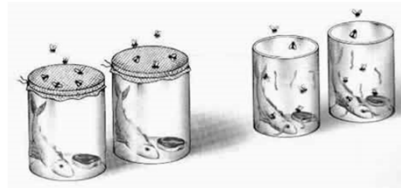
- ❖ **Spontaneous Generation:** the hypothesis that living organisms arise from nonliving matter is called.
 - a “**Vital Force**” Forms life. (*Élan vital*)

- ❖ **Biogenesis:** Alternative hypothesis, that the living organisms arise from preexisting life.

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Evidence Pro and Con - 1

- 1) **1668: Francesco Redi** filled six jars with decaying meat.



| <u>Conditions</u> | <u>Results</u> |
|------------------------------|-------------------|
| 3 jars covered with fine net | No maggots |
| 3 open jars | Maggots appeared |

- From where did the maggots come?
- What was the purpose of the sealed jars?
- *Spontaneous generation or biogenesis?*

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Evidence Pro and Con - 2

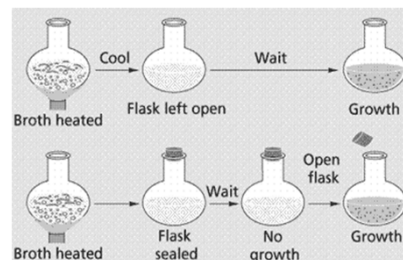
- 2) **1745: John Needham** put boiled nutrient broth into covered flasks.

| <u>Conditions</u> | <u>Results</u> |
|---|-------------------------|
| Nutrient broth heated, then placed in sealed flask | <u>Microbial growth</u> |
| <ul style="list-style-type: none"> • From where did the microbes come? • <i>Spontaneous generation or biogenesis?</i> | |

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Evidence Pro and Con - 3

- 3) **1765: Lazzaro Spallanzani** boiled nutrient solutions in flasks.



| <u>Conditions</u> | <u>Results</u> |
|--|-----------------------------------|
| Nutrient broth placed in flask, heated, then sealed | <i>No microbial growth</i> |
| <ul style="list-style-type: none"> • <i>Spontaneous generation or biogenesis?</i> | |

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Evidence Pro and Con - 4

- 4) **1861: Louis Pasteur** demonstrated that microorganisms are present in the air.
- *The air itself did not create the microbes/life.*

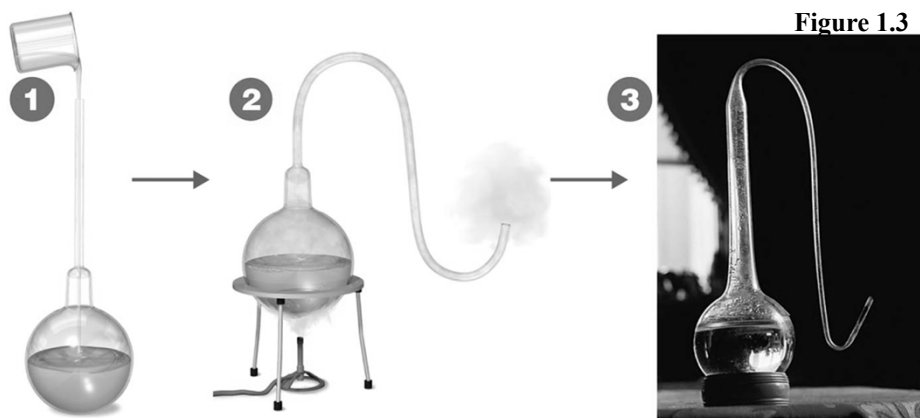
| <u>Conditions</u> | <u>Results</u> |
|---|----------------------------|
| Nutrient broth placed in flask, heated, not sealed | Microbial growth |
| Nutrient broth placed in flask, heated, then sealed | No microbial growth |

• **Spontaneous generation or biogenesis?**

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C. The Theory of Biogenesis

- (4b.) Pasteur's **S-shaped** ("goose-necked") flask kept microbes out but let air in.



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❖ *What would be a proper CONTROL experiment, to prove these results??*

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1.3) The Golden Age of Microbiology

• 1857-1914

- Beginning with Pasteur's work, discoveries included:
 - **Food spoilage** – souring wine and beer
 - Yeast fermentation = causative
 - → the relationship between microbes & disease,
 - **immunity**, and
 - **antimicrobial drugs**



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A. Fermentation & Pasteurization

- Pasteur showed that microbes are responsible for fermentation.
 - Fermentation is the conversion of sugar to alcohol to make beer and wine.
- Microbial growth is also responsible for spoilage of food.
 - Bacteria that use alcohol and produce acetic acid spoil wine by turning it to vinegar (acetic acid).

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Fermentation & Pasteurization

1. Pasteur demonstrated:

- **spoilage bacteria could be killed by heat**
 - a heat not hot enough to evaporate the alcohol in wine.
- This application of a high heat for a short time is called **Pasteurization**.



Louis Pasteur (1822-1895)
Demonstrated that life did not arise spontaneously from nonliving matter.

Figure 1.4

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B. The Germ Theory of Disease

2. **1835**: **Agostino Bassi** showed a silkworm disease was caused by a fungus.
3. **1865**: **Pasteur** produced evidence that another silkworm disease was caused by a protozoan.
4. **1840s**: **Ignaz Semmelweis**
 - advocated *hand-washing* to prevent transmission of *puerperal fever* from one OB patient (mother) to another.
 - *Streptococcus pyogenes*



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The Germ Theory of Disease

5. **1860s: Joseph Lister** used a chemical disinfectant to prevent surgical wound infections

- after looking at Pasteur's work showing microbes are in the air, can spoil food, and cause animal diseases.



6. **1876: Robert Koch** provided proof that a bacterium causes anthrax and provided the experimental steps,

❖ ***Koch's postulates***: used to prove that a specific microbe causes a specific disease.

1. Find microbe present in every case of the disease;
2. Isolate pure organism from sick host animals;
3. Inoculate organism into healthy host → get disease;
4. Reisolate pure organism from newly/expt'l sick animals.



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Koch

C. Vaccination

7. **1796: Edward Jenner** inoculated a person with cowpox virus. The person was then protected from smallpox.

- Called ***vaccination*** from *vacca* for cow
- The protection is called immunity

http://www.nlm.nih.gov/exhibition/smallpox/sp_vaccination.html

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D. The Birth of Modern Chemotherapy



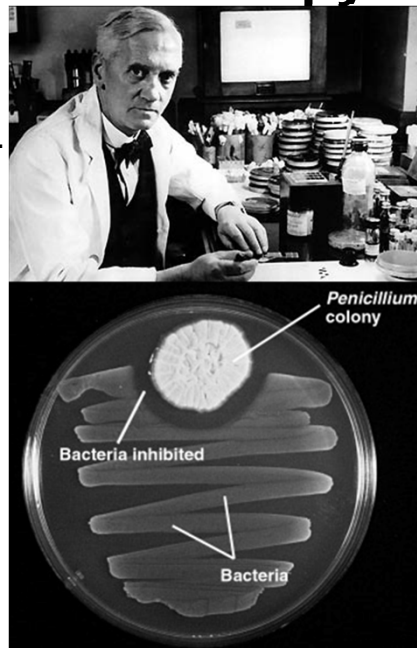
- Treatment with chemicals is **chemotherapy**.
 - Chemotherapeutic agents used to treat infectious disease can be synthetic drugs or antibiotics.
 - **Antibiotics** are chemicals produced by bacteria and fungi that inhibit or kill other microbes.
 - Quinine from tree bark was long used to treat malaria.
8. **1910: Paul Ehrlich** developed a synthetic arsenic drug, salvarsan, to treat **syphilis**.
- 1930s: Sulfonamides were synthesized.

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Birth of Modern Chemotherapy

9. **1928: Alexander Fleming** discovered the first antibiotic.

- He observed that ***Penicillium*** fungus made an antibiotic, penicillin,
 - killed ***S. aureus***.
- 1940s: Penicillin was tested clinically, and mass produced!



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1.4) Modern Developments in Microbiology

- **Bacteriology** is the study of bacteria.
- **Mycology** is the study of fungi.
- **Parasitology** is the study of protozoa and parasitic worms.
- Recent advances in genomics, the study of an organism's genes, have provided new tools for classifying microorganisms.

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Modern Developments: Immunology & Virology

- **Immunology** is the study of acquired resistance to disease.
 - Vaccines and interferons are being investigated to prevent and cure viral diseases.
- **1933: Rebecca Lancefield** proposed the use of immunology to identify some bacteria according to **serotypes** -
 - (variants within a species = “strains” or “subspecies”).
- **Virology** is the study of viruses.



Figure 1.4

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