Microbial Growth

Microbial Growth

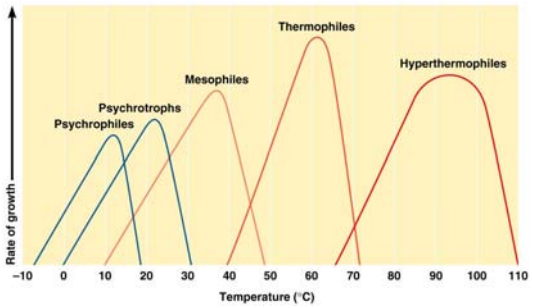
- Microbial growth is the increase in number of cells, not cell size

The Requirements for Growth: Physical Requirements

- Temperature
  -
  - Optimum growth temperature
  -

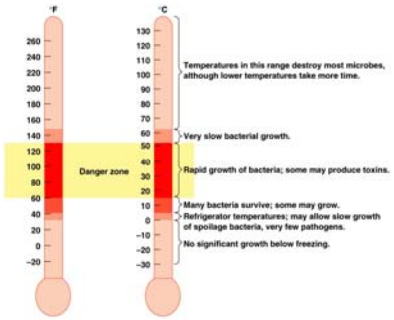
Temperature Category

- **Psychrophiles**
  - like it cold, just below freezing, up to ~20 °C
- **Psychrotrophs**
- Grow between 0°C-20 and up to 30°C
  -
  -
  - Cause food spoilage
- **Mesophiles**
- prefer moderately warm temps, ~20°C - 45°C
- **Thermophiles**
  -



Psychrotrophs

- Grow between 0°C and 20-30°C
-



- **pH**
  - Most bacteria grow between pH 6.5 and 7.5
  - Molds and yeasts grow between pH 5 and 6
  -

- **Osmotic Pressure**
  - Hypertonic environments, increase salt or sugar, cause plasmolysis
  - Extreme or obligate halophiles require high osmotic pressure
  - Facultative halophiles tolerate high osmotic pressure

- **Halophiles - salt loving**
  - salt conc. in body ~
  - salt conc. in ocean ~
  - salt conc. in Dead Sea and Great Salt Lake ~

The Requirements for Growth: Chemical Requirements

- **Carbon**
  - Structural organic molecules, energy source
  - Chemoheterotrophs use organic carbon sources
  -
- N, S, P

- **Trace elements**
  - Inorganic elements required in small amounts
  -

$$O_2^- + 2\,H^+ \xrightarrow{\text{superoxide dismutase}} H_2O_2 + O_2$$

Toxic Forms of Oxygen

- Singlet oxygen: O_2 boosted to a higher-energy state
- Superoxide free radicals:

- Peroxide anion:
- Hydroxyl radical (OH•)

$$2\,H_2O_2 \xrightarrow{\text{catalase}} 2\,H_2O + O_2$$

$$H_2O_2 + 2\,O^+ \xrightarrow{\text{peroxidase}} 2\,H_2O$$

The Requirements for Growth: Chemical Requirements

- Organic growth factors
  - Organic compounds obtained from the environment
  - Vitamins, amino acids, purines, and pyrimidines

Culture Media

- Culture medium: Nutrients prepared for microbial growth
- Sterile:
- Inoculum: Introduction of microbes into medium
- Culture: Microbes growing in/on culture medium

Agar

-
- Used as solidifying agent for culture media in Petri plates, slants, and deeps
- Generally not metabolized by microbes
- Liquefies at 100°C
- Solidifies ~

Culture Media

- Chemically defined media (_____): Exact chemical composition is known
- Complex media (_____): Extracts and digests of yeasts, meat, or plants
  - Nutrient broth
  - Nutrient agar

Anaerobic Culture Methods

- Reducing media
  - Contain chemicals (thioglycollate or oxyrase) that combine O_2
  -
- Anaerobic jar
- Anaerobic chamber

Capnophiles: Require High CO_2

- Candle jar
- CO_2-packet

Selective Media

- Suppress unwanted microbes and encourage desired microbes.

Differential Media

- Make it easy to distinguish colonies of different microbes.

Colonies

- A pure culture contains only one species or strain.
- A colony is a population of cells arising from a single cell or spore or from a group of attached cells.
- A colony is often called a colony-forming unit (_____).

Streak Plate

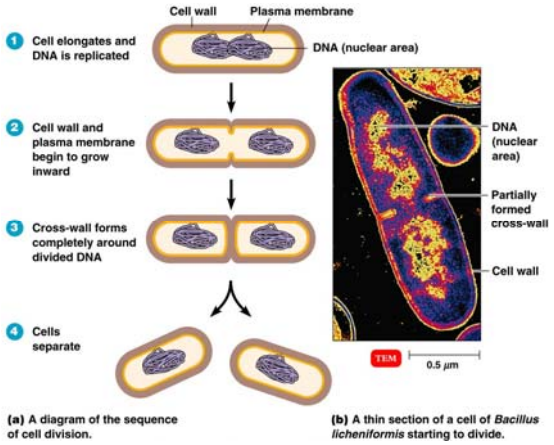
- Technique for separating bacteria to obtain discrete, isolated colonies.

Preserving Bacteria Cultures

-
- Lyophilization (freeze-drying): Frozen (_____) and dehydrated in a vacuum

Reproduction in Prokaryotes

-
-
- Conidiospores (actinomycetes)
- Fragmentation of filaments



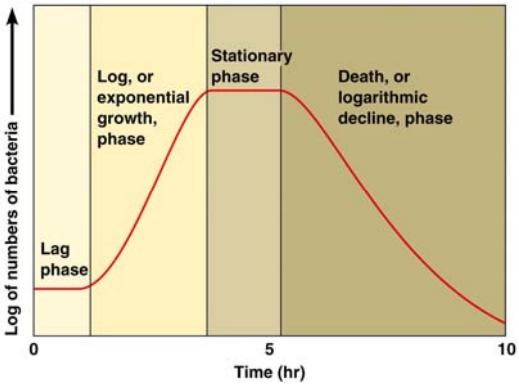
Binary Fission

Exponential Growth Curve

- - batch culture - closed system, nothing added or removed
- - 4 phases - 1)
- 2)
- 3) stationary
- 4)

Exponential Growth Curve

- 1) lag - bacteria gearing up metabolically
- 2) log - division begins, exponential
- 3) stationary -
  - rate of cell division =
  - nutrients being used up, wastes accumulating
  - cells surviving not dividing, endospores forming
- 4) death - cells aging, starving, toxic environment



- The graph represents a closed system =
- continuous culture - fresh nutrients and media added while some old culture removed =
  - continual state of exponential growth

Direct Measurements of Microbial Growth

- Plate counts: Perform serial dilutions of a sample
- Inoculate Petri plates from serial dilutions
- After incubation, count colonies on plates that have 25-250 (_____) colonies (CFUs)

Bonus Question on Exam

- calculating bacterial generation times

Initial # cells X $2^{\text{number of generations}}$ = total # cells

$$\text{number of generations} = \frac{(\log_{\text{cells at end}}) - (\log_{\text{cells at beginning}})}{0.301}$$

You learn on your own. I will give you practice problems.

Study Objectives

1. Discuss the exponential growth curve and indicate what is occurring during each of the 4 phases.
2. Describe how temperature affects the growth of bacteria. Relative to temperature, how are these organisms classified?
3. Describe how pH affects the growth of bacteria. Relative to pH, how are these organisms classified?
4. Compare and contrast aerobes, anaerobes (facultative, obligate and aerotolerant), and microaerophiles. How does each deal with toxic oxygen molecules?
5. Describe the types of toxic oxygen molecules and the enzymes that degrade them.
6. Distinguish between chemically defined (synthetic) and complex (non-synthetic) media.
7. Distinguish between selective and differential media.
8. How is a capnophile different from a strict anaerobe and microaerophile?
9. Compare and contrast a batch culture with a continuous culture.
10. Describe the 4 methods of bacterial reproduction.