

Chapter 7

Topics

- Microbial Growth
- Factors that affect microbial growth
- Microbial Nutrition

Microbial Growth

- Binary fission
- Generation time
- Growth curve
- Enumeration of bacteria

Definition of growth

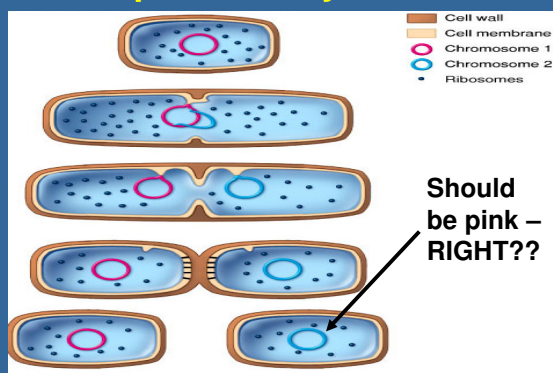
- Unicellular organisms increase in size to approximately two times the original size
- At that time the mother cell divides into two daughter cells by binary fission
- The daughter cells grow - become mother cells and divide

With each division, the population doubles

Binary fission

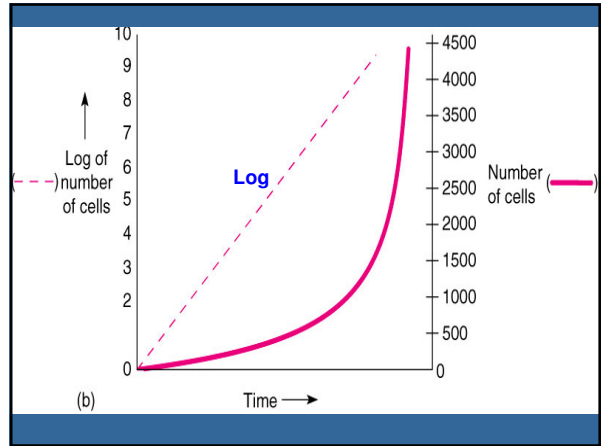
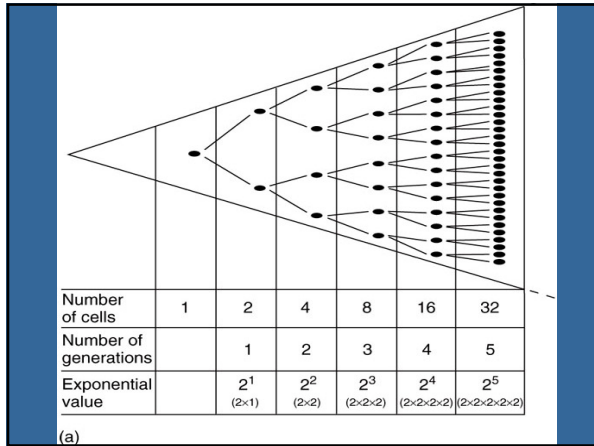
- The division of a bacterial cell
- Parental cell enlarges and duplicates its DNA
- Septum formation divides the cell into two separate chambers
- Complete division results in two **identical** cells

Steps in Binary Fission

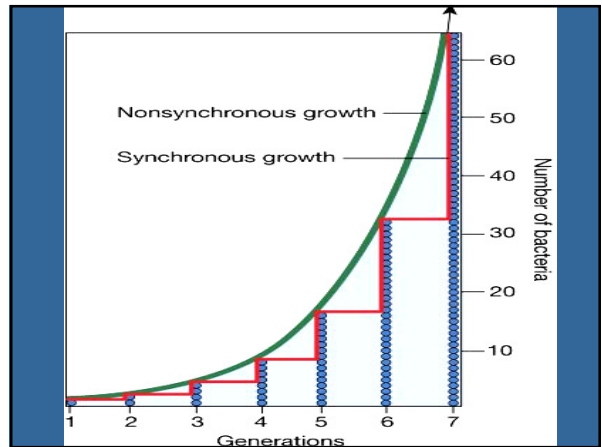


Generation time

- The time required for a complete division cycle (doubling)
- Length of the generation time is a measure of the growth rate
- Exponentials are used to define the numbers of bacteria after growth

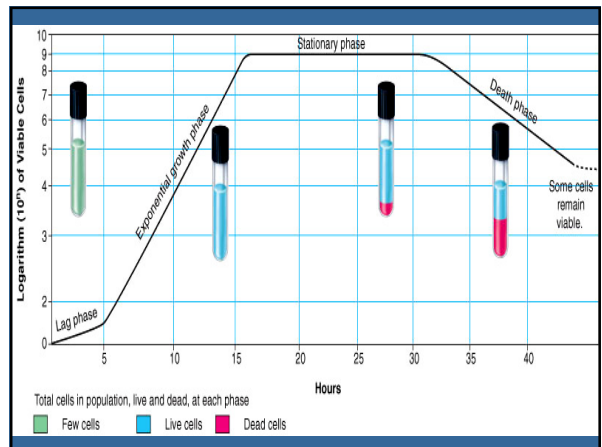


Synchronous growth vs. nonsynchronous growth



Growth curve

- Lag phase
- Log phase
- Stationary phase
- Death phase



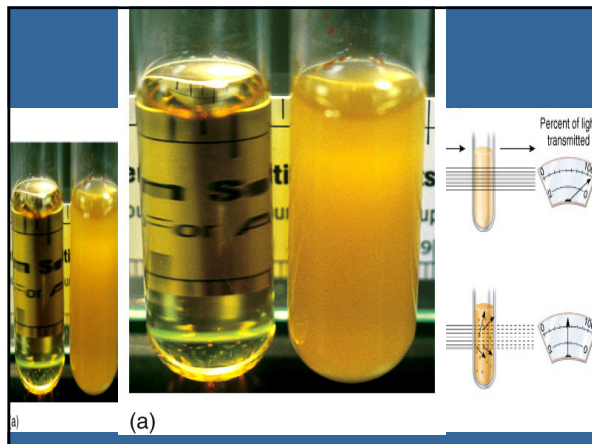
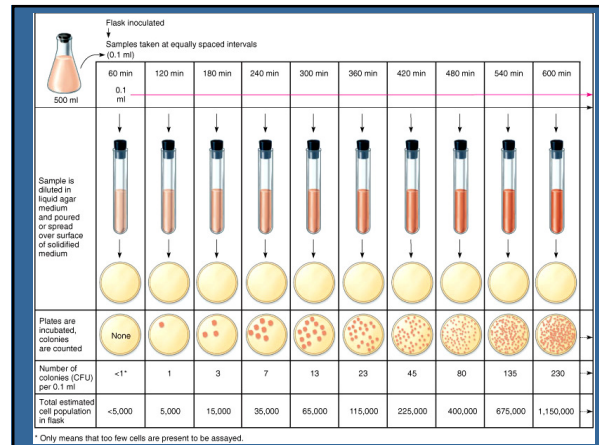
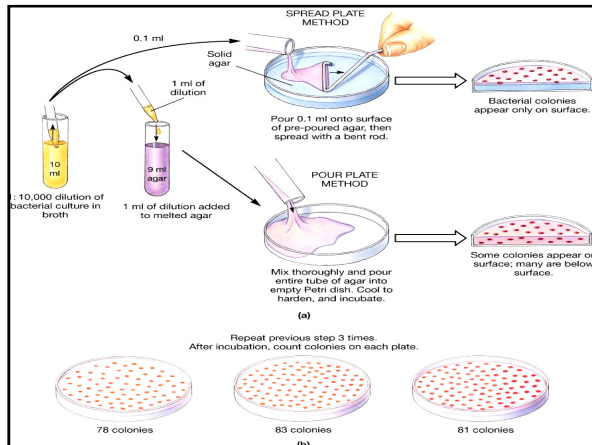
Enumeration of bacteria

- Direct cell count - multiple methods
 - Turbidity
 - Automated devices
 - Coulter counter
 - Flow cytometer
- Differences in techniques - can you tell the difference between live/dead?

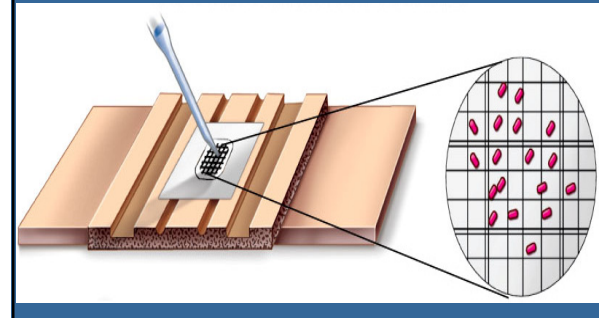
One bacterium results in one bacterial colony

Countable number of colonies

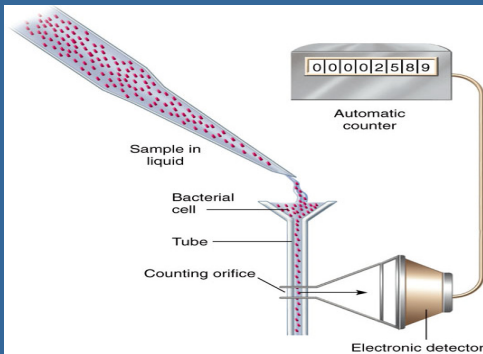
Limitation = 30 to 300 per plate



Direct counts by microscopy - can take advantage of staining techniques we learned in Chapter 3



Mechanical or automated counters



Factors that Effect Microbial Growth

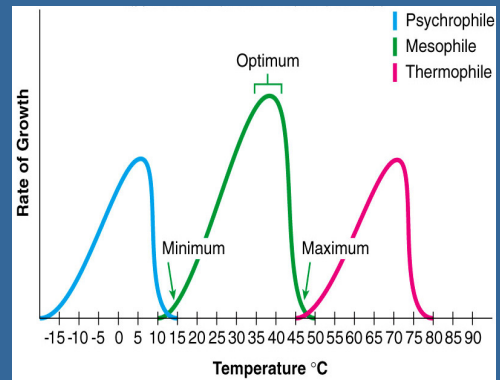
- Temperature
- Gas
- pH
- Osmotic pressure
- Other factors
- Microbial association

Temperature - Figure 7.8

- **Psychrophiles** obligate (*Bacillus globisporus*), facultative (*Xanthomonas pharmicola*) – optimal temperature for growth below 15 °C

- **Mesophiles** - 20 to 40°C - thermophilic organisms can survive elevated temperatures, but grow best at moderate temperatures

- **Thermophiles** – organisms that normally grow best at >45 °C



Gases

- Two gases that most influence microbial growth
 - Oxygen
 - Respiration
 - Oxidizing agent
 - Carbon dioxide

Oxygen -

- Obligate aerobes
- Obligate anaerobes
- Facultative anaerobes
- Microaerophiles - do not grow at normal atmospheric concentrations of O₂- soil microorganisms
- Capnophiles - microaerophiles that are CO₂ loving

Obligate aerobe

- Requires oxygen for metabolism
- Possess enzymes that can neutralize the toxic oxygen metabolites
 - Superoxide dismutase and catalase
- Ex. Most fungi, protozoa, and bacteria

Facultative anaerobe

- Does not require oxygen for metabolism, but can grow in its presence
- During oxygen limitation states, anaerobic respiration or fermentation occurs
- Possess superoxide dismutase and catalase
- Ex. **Gram negative pathogens**

Obligate anaerobes

- Cannot use oxygen for metabolism
- Do not possess superoxide dismutase and catalase
- The presence of oxygen is toxic to the cell
- Ex - dental pathogens, intestinal pathogens, deep in tissues

pH

pH - negative logarithm of the hydrogen ion concentration of an aqueous solution

- Most cells grow best between pH 6 - 8
- Exceptions would be acidophiles (pH 0) and alkaliphiles (pH 10).

Osmotic pressure

- Halophiles
- Require high salt concentrations
- Withstand hypertonic conditions
- Ex. *Halobacterium*
- Facultative halophiles
 - Can survive high salt conditions but is not required
 - Ex. *Staphylococcus aureus*

Other factors?

- **Barophiles** – withstand high pressures
- **Spores and cysts**- can survive dry habitats

Hydrostatic pressure

Most microorganisms can withstand reasonable pressures, but barophiles are highly evolved microorganisms that grow only at intense pressure

Some barophiles are also thermophiles - deep thermal vents in oceans

Ecological association

- Influence microorganisms have on other microbes
 - Symbiotic relationship
 - Non-symbiotic relationship
- Organisms that live in close nutritional relationship
- Types
 - Mutualism – both organism benefit
 - Commensalism – one organisms benefits
 - Parasitism – host/microbe relationship

Ecology of Communities Clint Eastwood Style

Good – help each other in community setting

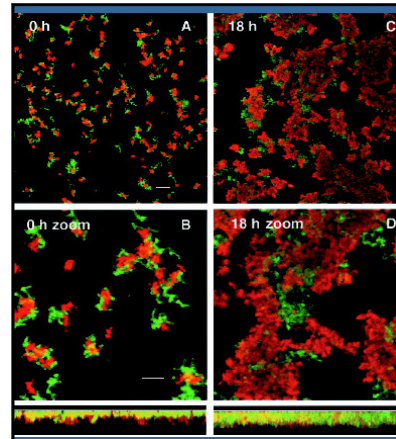
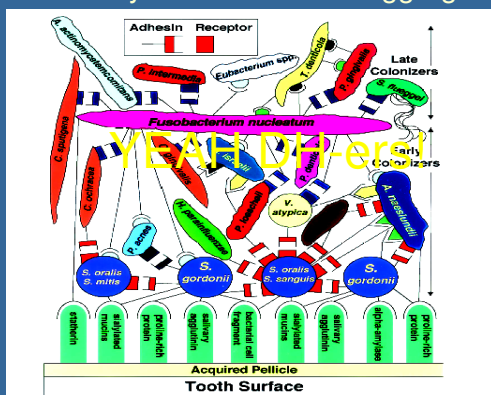
Bad – kill one another with antibiotics – take spoils of victory

Ugly – live together to cause disease



Figure 170
Clinical features of *Staphylococcus aureus* infections. (a) Folliculitis, inflammation of a hair follicle. (b) A child with impetigo. (c) Gum tissue injury (necrosis) associated with penicillin-resistant staphylococci. (From H. Helouvo, K. Kakkariainen, and K. Pannio. *Oral Microbiol. Immuno.* 8(1993):75-79.)

Oral cavity biofilms and Co-aggregation



Two Species
Biofilm
Formed by:
S. oralis &
A. naeslundii

Microbial Nutrition

- Sources of essential nutrients
 - **Macronutrients:** Carbon, Nitrogen, Oxygen, and Hydrogen
 - **Micronutrients:** Magnesium, Manganese, Zinc, and Nickel
- Transport mechanisms

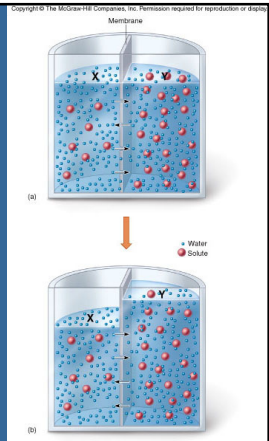
Carbon source

- **Heterotroph (depends on other life forms)**
 - Organic molecules
 - Ex. Sugars, proteins, lipids
- **Autotroph (self-feeders)**
 - Inorganic molecules
 - Ex. CO₂

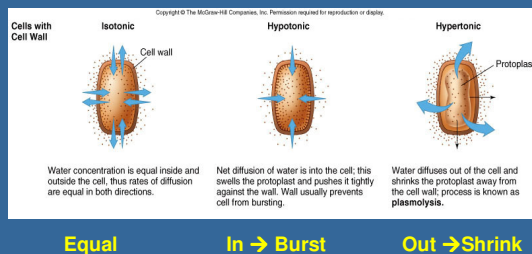
Transport mechanisms

- Osmosis
- Diffusion
- Active transport
- Endocytosis

- Water movement
- Selectively permeable membrane
- Concentration gradient



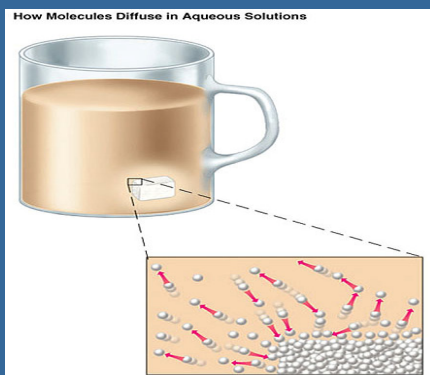
Osmosis – water movement



Diffusion

- Net movement of molecules from a high concentrated area to a low concentrated area
- **No energy** is expended (passive)
- Concentration gradient and permeability affect movement

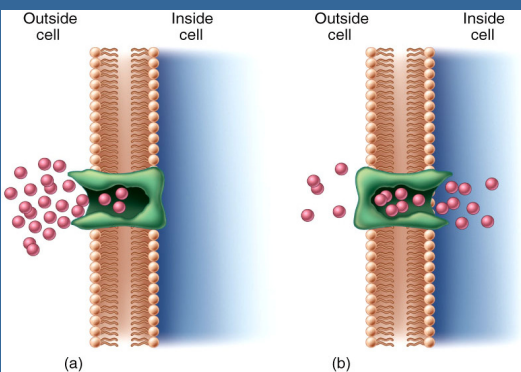
Sugar diffusion in coffee



Facilitated diffusion

- Transport of polar molecules and ions across the membrane
- No energy is expended (passive)
- Carrier protein facilitates the binding and transport
 - Specificity
 - Saturation
 - Competition

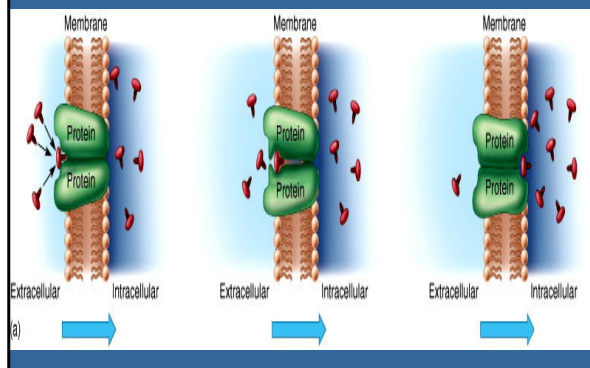
Facilitated diffusion



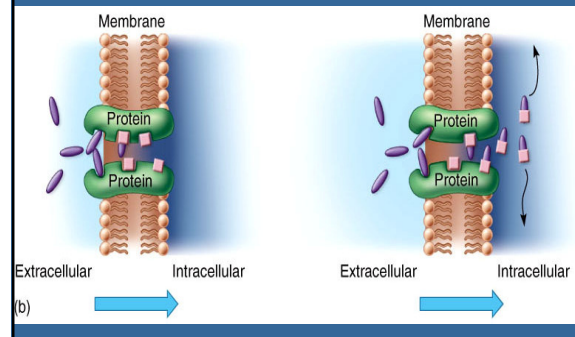
Active transport

- Transport of molecules **against a gradient**
- **Requires energy (active)**
- Ex. **Permeases** and protein pumps transport sugars, amino acids, organic acids, phosphates and metal ions
- Ex. **Group translocation** transports and modifies specific sugars

Permeases

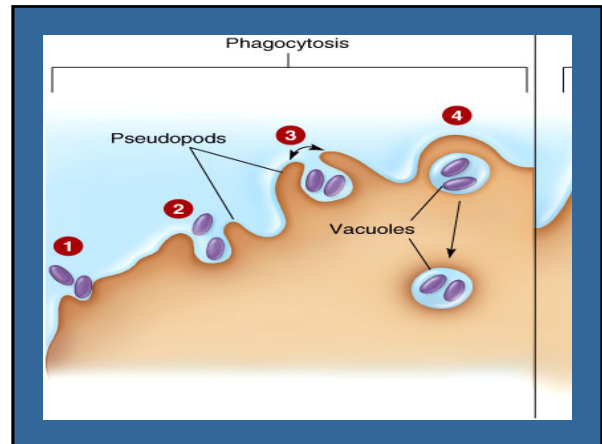


Group translocation - usually entities are modified



Endocytosis

- Substances are taken, but are not transported through the membrane.
- Requires energy (active)
- Common for **eukaryotes**
- Ex. **Phagocytosis**, pinocytosis



In summary

The growth and division of microorganisms requires a carefully choreographed arrangement of a large number of processes. Little things can be exceedingly complex.