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

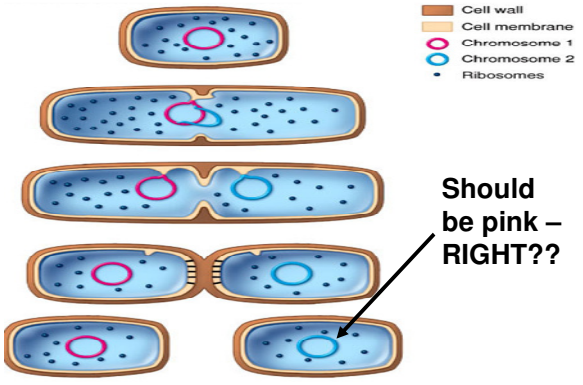
- The daughter cells grow - become mother cells and divide

With each division, the population doubles

Binary fission

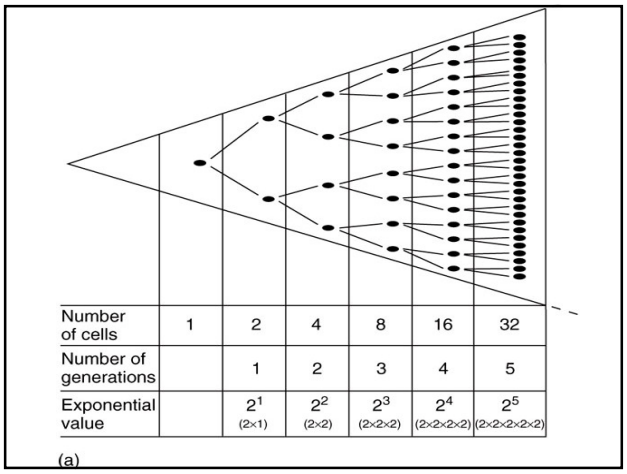
- **The division of a bacterial cell**
- **Parental cell enlarges and duplicates its DNA**
- **Septum formation divides the cell into two separate chambers**
- **Complete division results in two identical cells**

Steps in Binary Fission



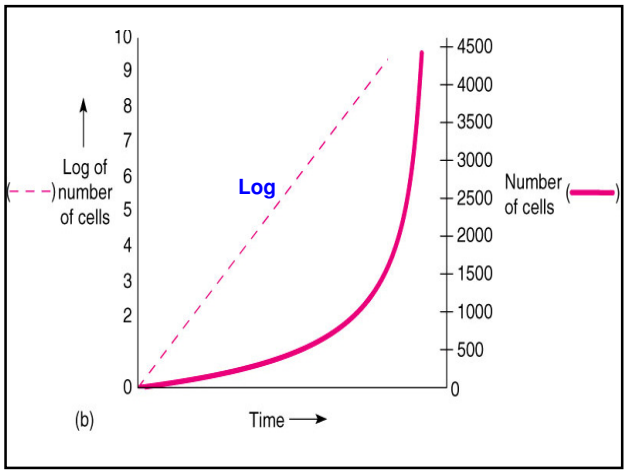
Generation time

- **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**

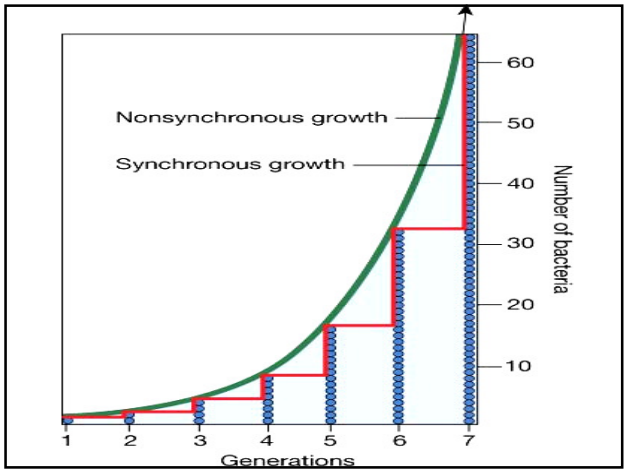


Number of cells	1	2	4	8	16	32
Number of generations		1	2	3	4	5
Exponential value		2^1 (2×1)	2^2 (2×2)	2^3 (2×2×2)	2^4 (2×2×2×2)	2^5 (2×2×2×2×2)

(a)

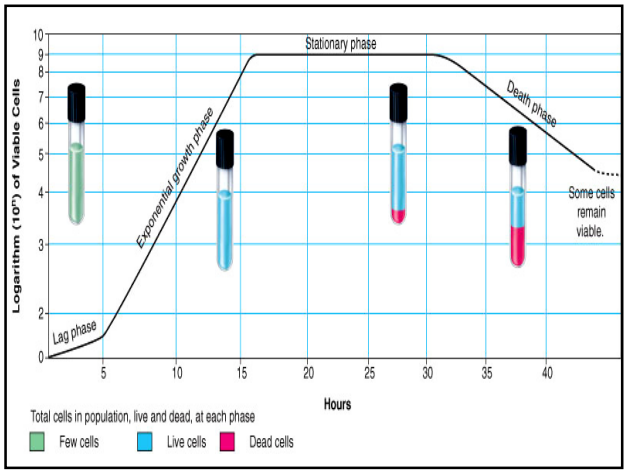


Synchronous growth vs. nonsynchronous growth



Growth curve

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



Enumeration of bacteria

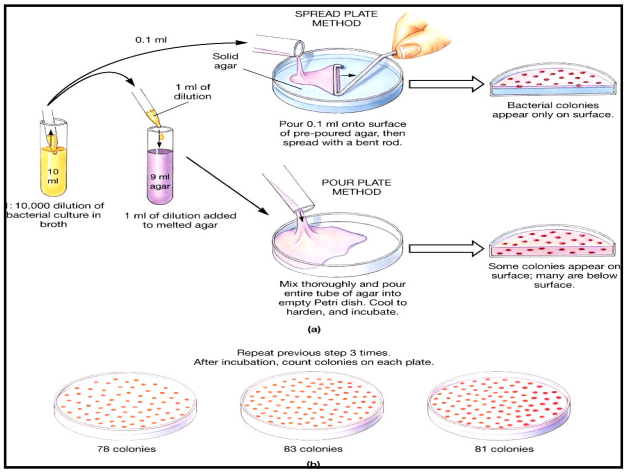
- **Direct cell count - multiple methods**
- **Turbidity**
- **Automated devices**
  - **Coulter counter**
  - **Flow cytometer**

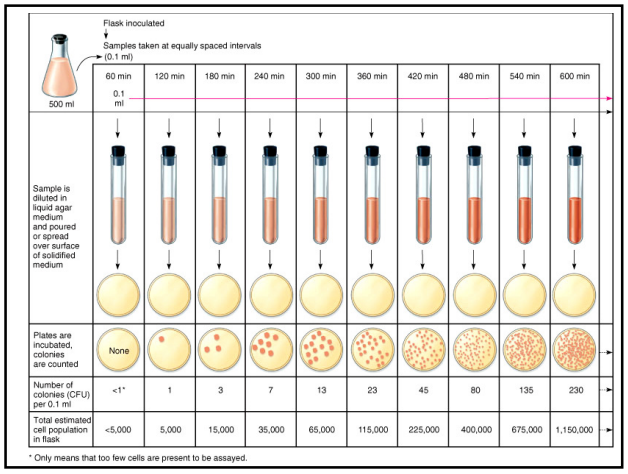
Differences in techniques - can you tell the difference between live/dead?

One bacterium results in one bacterial colony

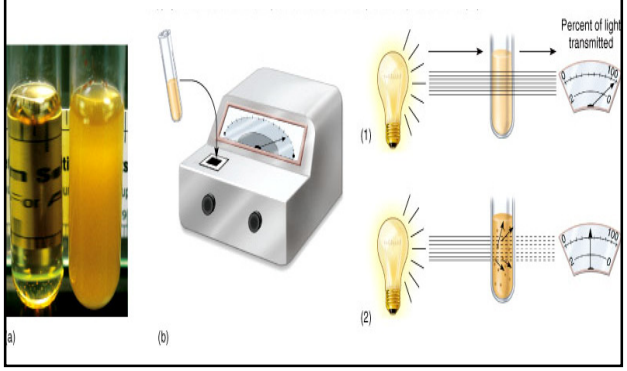
Countable number of colonies

Limitation = 30 to 300 per plate

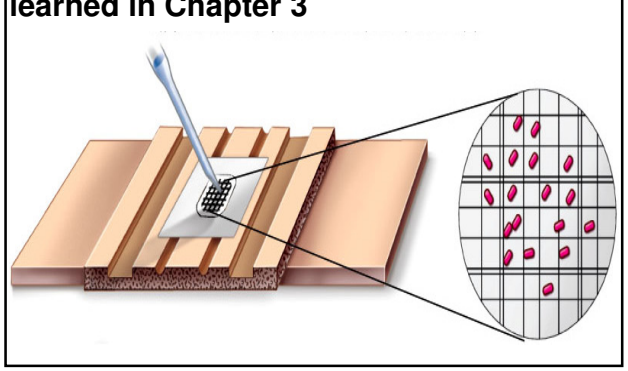




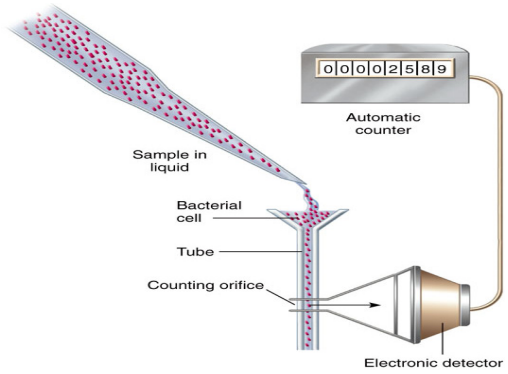
Turbidity



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



Mechanical or automated counters



Factors that Effect Microbial Growth

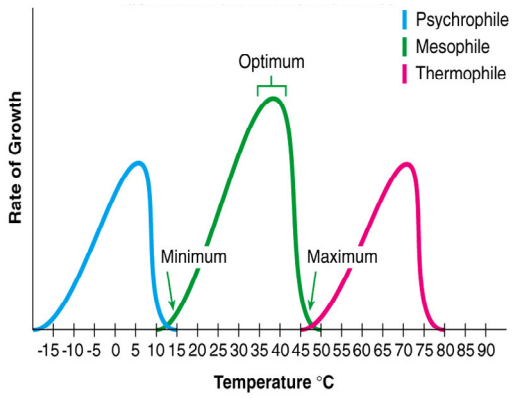
- **Temperature**
- **Gas**
- **pH**
- **Osmotic pressure**
- **Other factors**
- **Microbial association**

Temperature

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

- Mesophiles - 20 to 40°C - thermoduric 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 O_2- soil microorgansims

- **Capnophiles** - microaerophiles that are CO_2 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 alkalinophiles (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

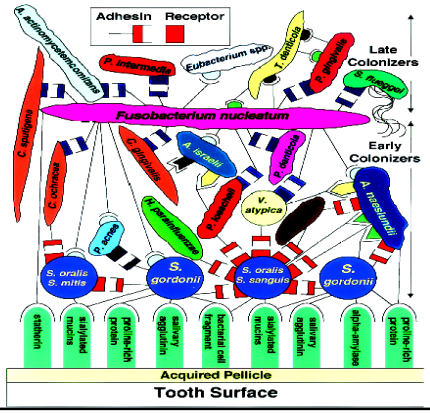
Bad – kill one another with antibiotics – take spoils of victory

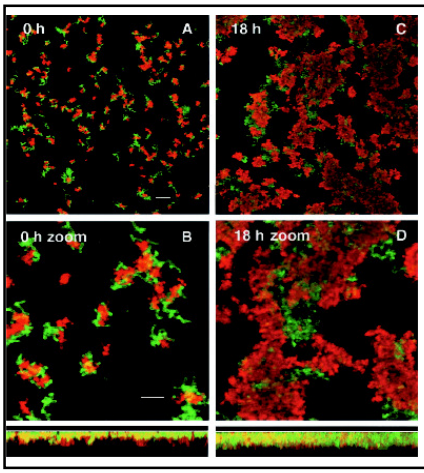
Ugly – live together to cause disease

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. Helovuo, K. Kakkarainen, and K. Pannio. *Oral Microbiol. Immuno.* 8(1993):75–79.)

Oral cavity biofilms and Co-aggregation





Two Species Biofilm Formed by: *S. oralis* & *P. acnes*

Microbial Nutrition

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

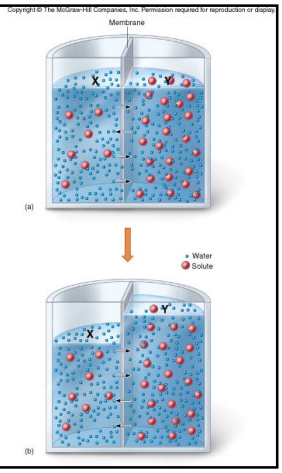
Carbon source

- Heterotroph (depends on other life forms)
  - Organic molecules
  - Ex. Sugars, proteins, lipids
- Autotroph (self-feeders)
  - Inorganic molecules
  - Ex. CO_2

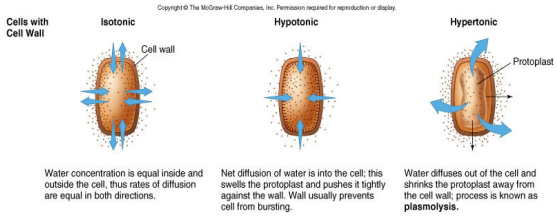
Transport mechanisms

- Osmosis
- Diffusion
- Active transport
- Endocytosis

- Water movement
- Selectively permeable membrane
- Concentration gradient



Osmosis – water movement

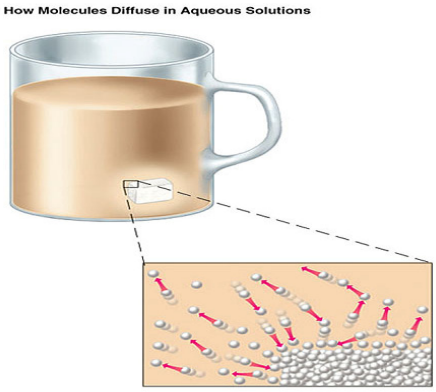


Equal | In → Burst | Out →Shrink

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

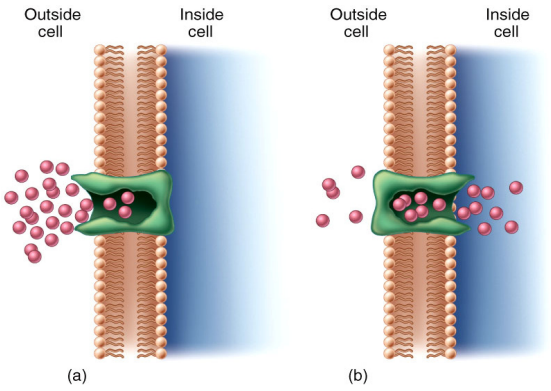
Sugar diffusion in coffee



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

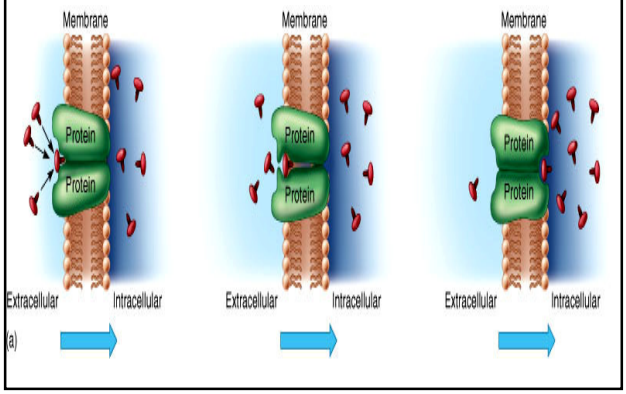
Facilitated diffusion



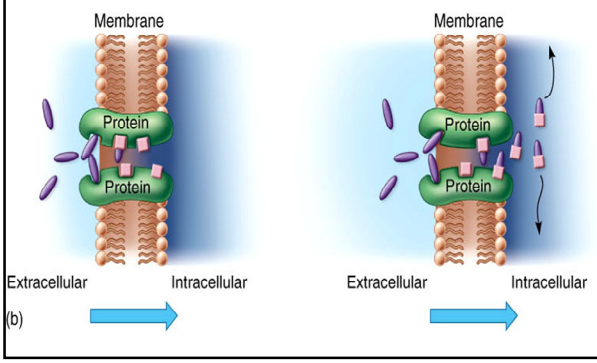
Active transport

- **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

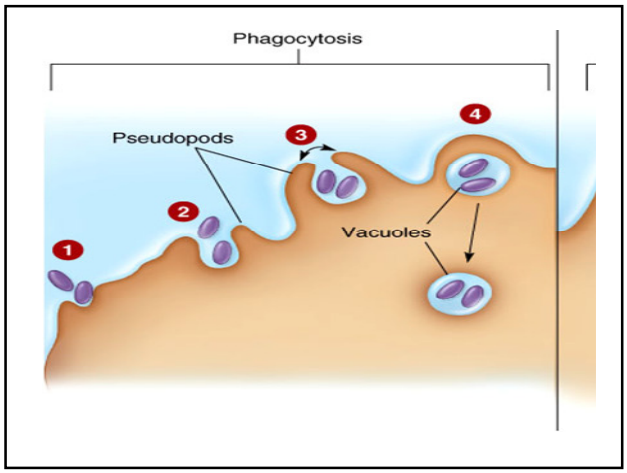


Group translocation - usually entities are modified



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.