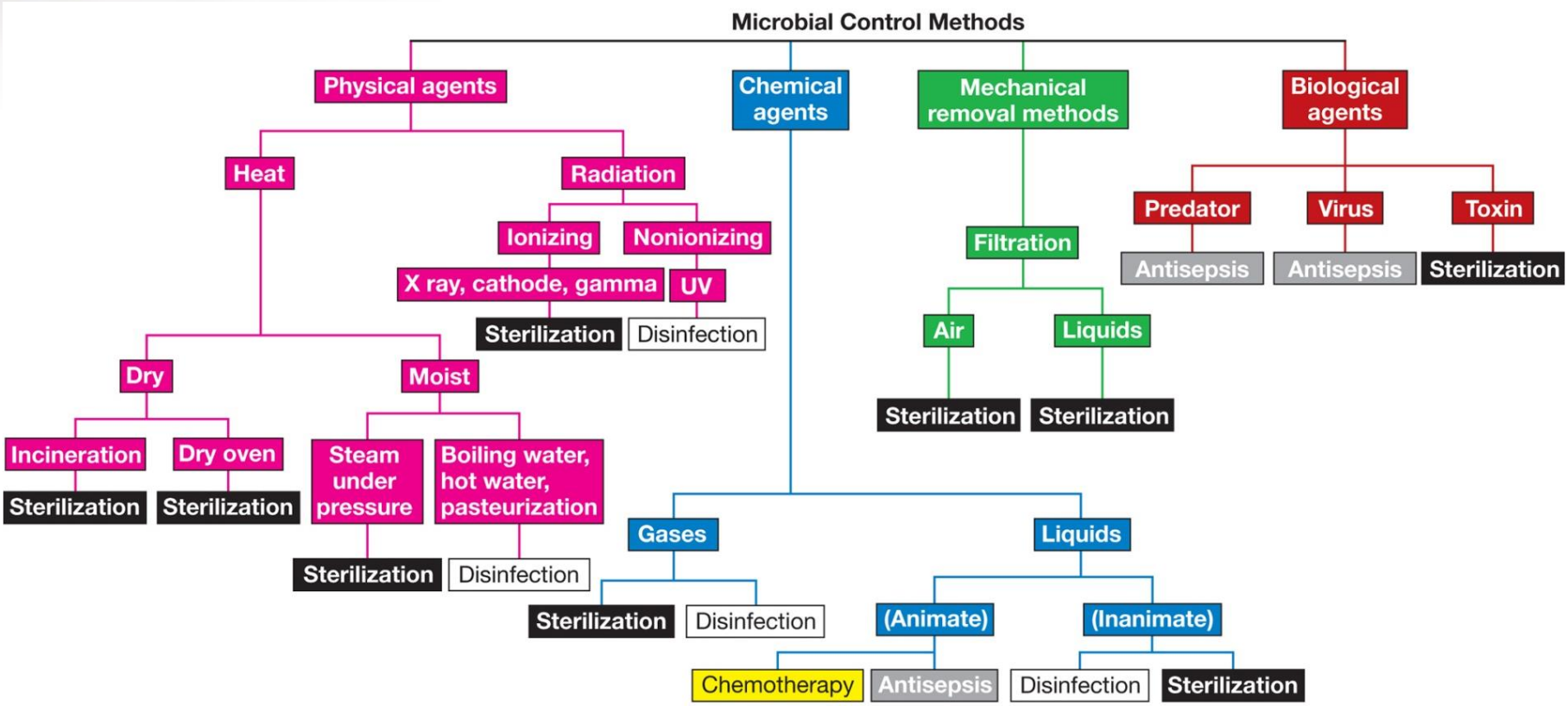
Physical control of Microorganisms in the Environment



Disinfection: The destruction or removal of vegetative pathogens but not bacterial endospores. Usually used only on inanimate objects.
Sterilization: The complete removal or destruction of all viable microorganisms. Used on inanimate objects.
Antisepsis: Chemicals applied to body surfaces to destroy or inhibit vegetative pathogens.
Chemotherapy: Chemicals used internally to kill or inhibit growth of microorganisms within host tissues.

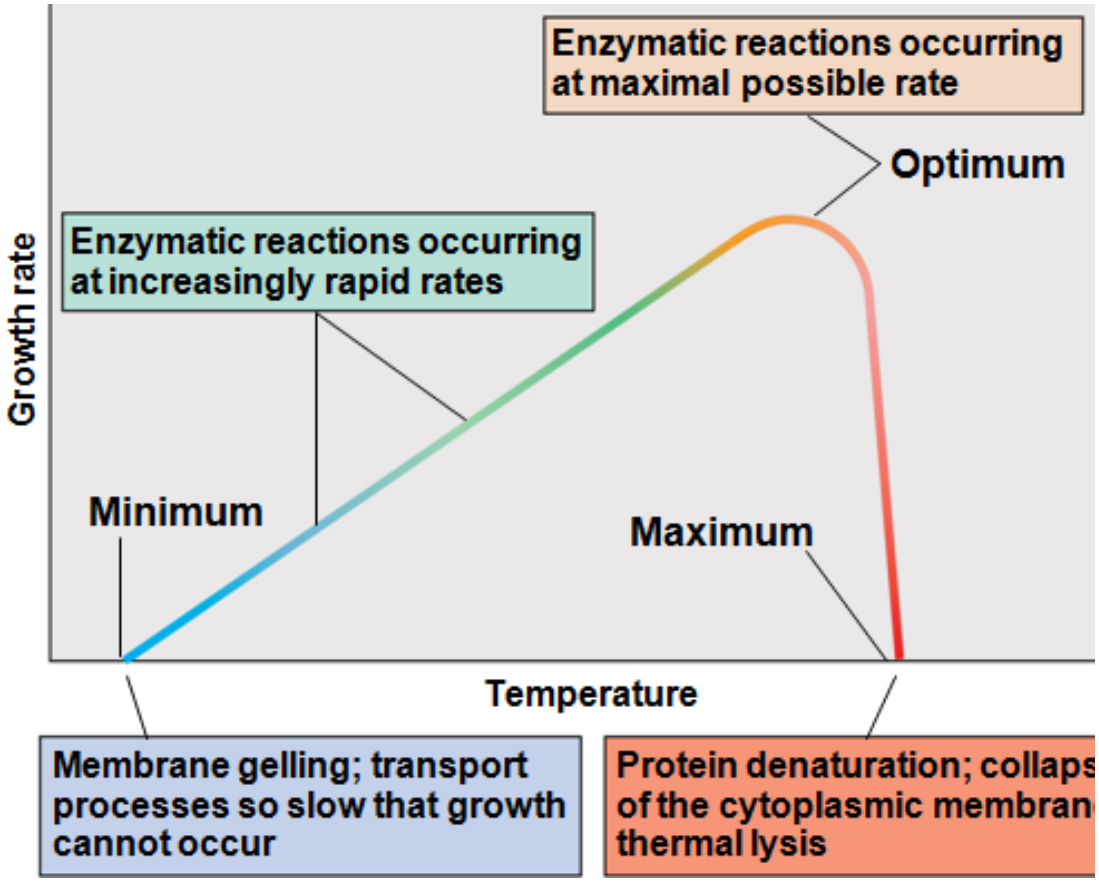
Physical Control Methods

- Heat (Moist & dry heat)
- Filtration
- Desication
- Osmotic pressure
- Radiation

Effect of Temperature on Growth

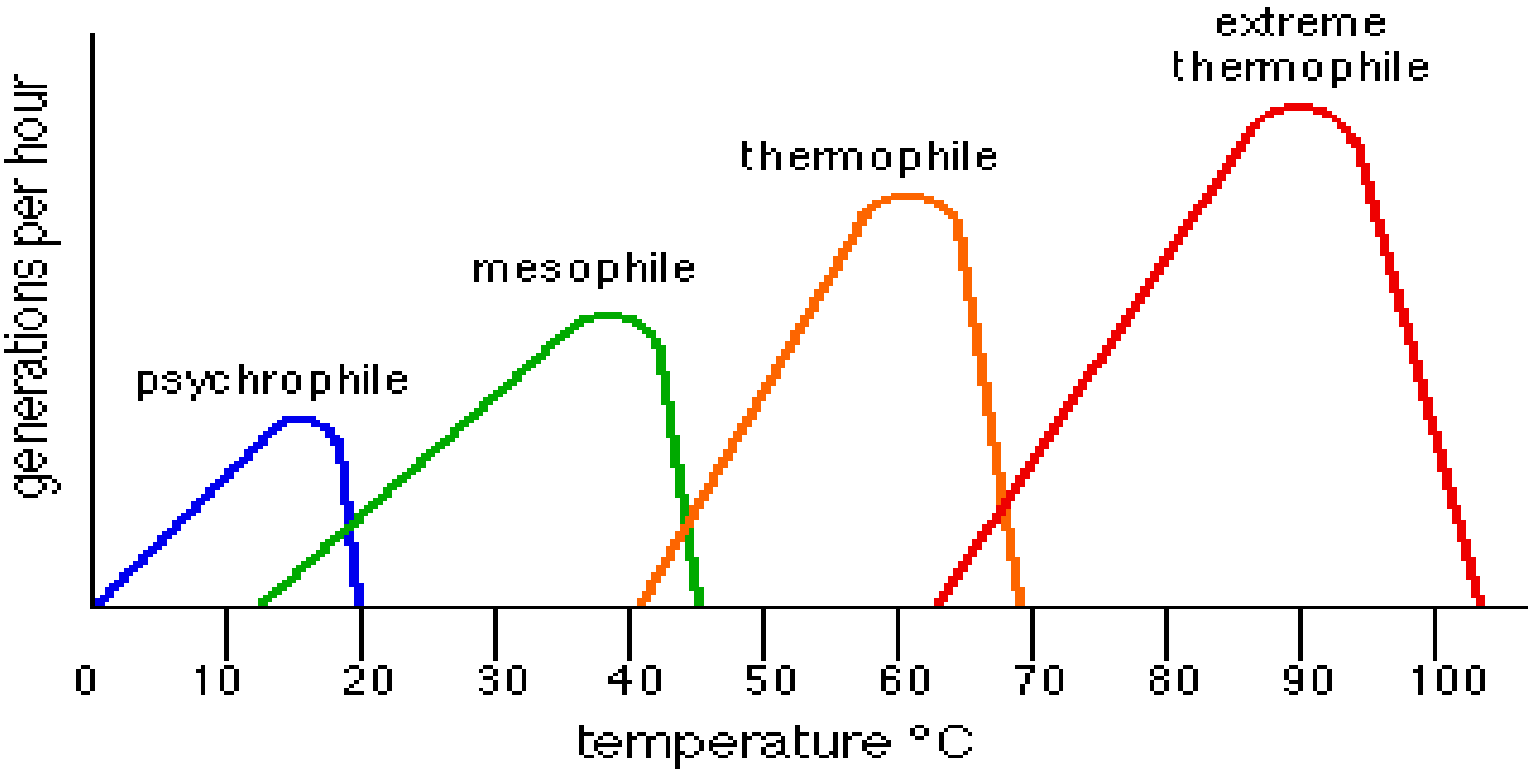
Cardinal temperatures: the minimum, optimum, and maximum temperatures at which an organism grows

Concept of static vs. Cidal



Environmental factors that influence growth

- **Psychrophiles**: the optimum Tº is LOW (below 15ºC)
- **Mesophiles**: optimum Tº in MEDIUM range
- **Thermophiles**: optimum Tº is HIGH (above 45ºC)
- **Hypertermophiles:** optimum Tº is VERY HIGH (above



Moist Heat

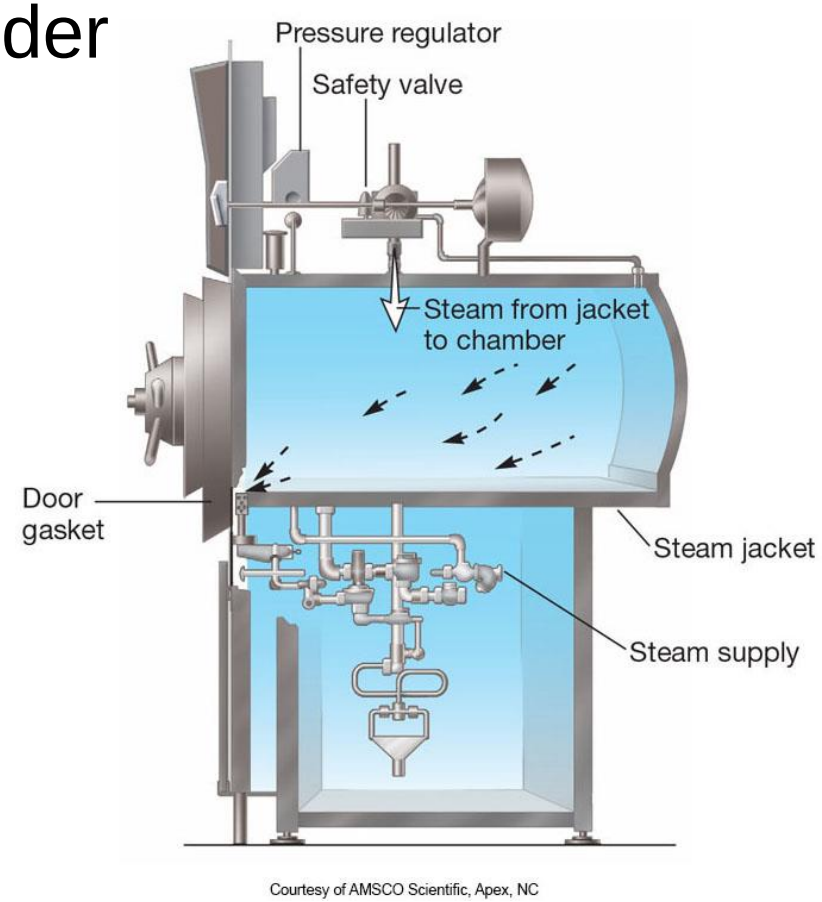
- Destroys viruses, fungi, and bacteria
- Boiling will not destroy spores and does not sterilize
- **Degrades nucleic acids, denatures proteins, and disrupts membranes**

Table 8.2	Approximate Conditions for Moist Heat Killing	
Organism	**Vegetative Cells**	**Spores**
Yeasts	5 minutes at 50–60°C	5 minutes at 70–80°C
Molds	30 minutes at 62°C	30 minutes at 80°C
Bacteria[1]	10 minutes at 60–70°C	2 to over 800 minutes at 100°C 0.5–12 minutes at 121°C
Viruses	30 minutes at 60°C	

1 Conditions for mesophilic bacteria.

Steam Sterilization

- Carried out above 100^{o}C which requires saturated steam under pressure
- Uses an autoclave
- Effective against all types of microorganisms (including spores!)
- Quality control - includes strips with *Geobacillus stearothermophilus*



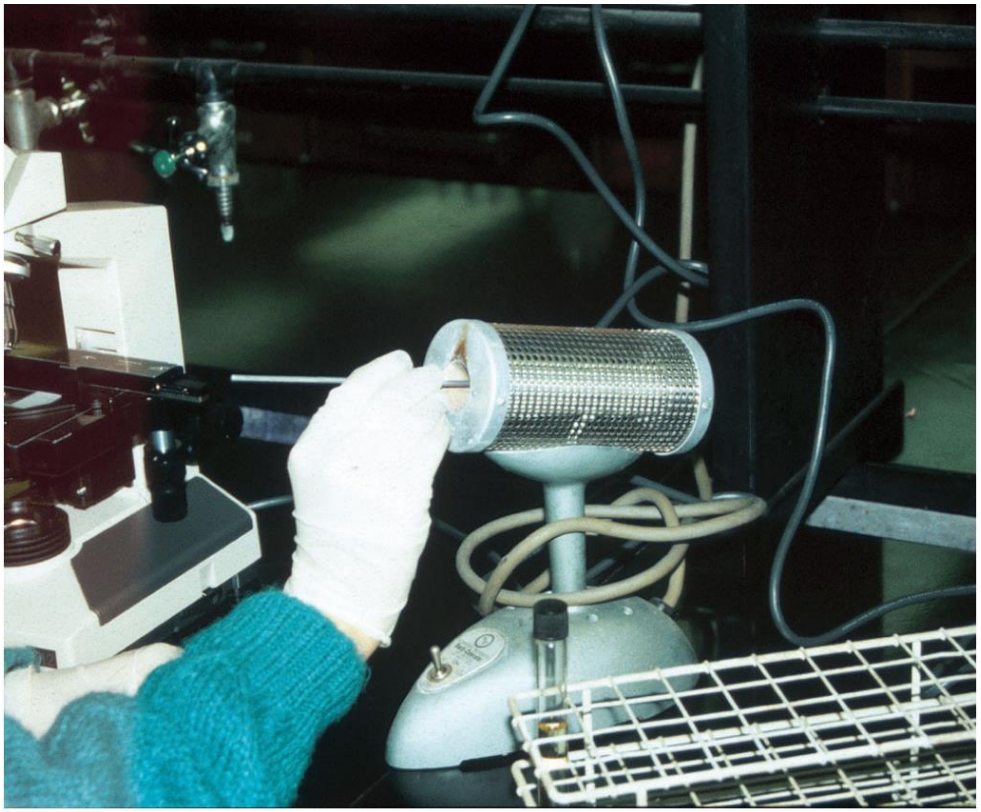
Courtesy of AMSCO Scientific, Apex, NC

Dry Heat Sterilization

- Less effective than moist heat sterilization, requiring higher temperatures and longer exposure times
  - items subjected to 160–170°C for 2 to 3 hours or 121°C for 16 hours
- **Oxidizes cell constituents and denatures proteins**

Dry Heat Incineration

- Bench top incinerators are used to sterilize inoculating loops used in microbiology laboratories



Pasteurization

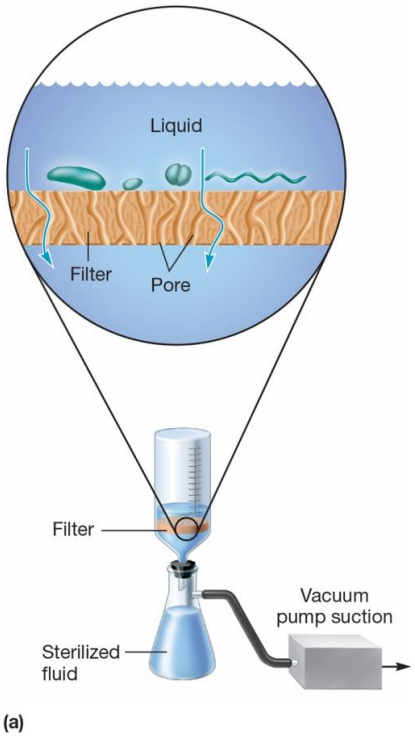
- Controlled heating at temperatures well below boiling
- Used for milk, beer, and other beverages
- Process **does not sterilize** but **does kill pathogens present and slow spoilage by reducing the total load of organisms present**

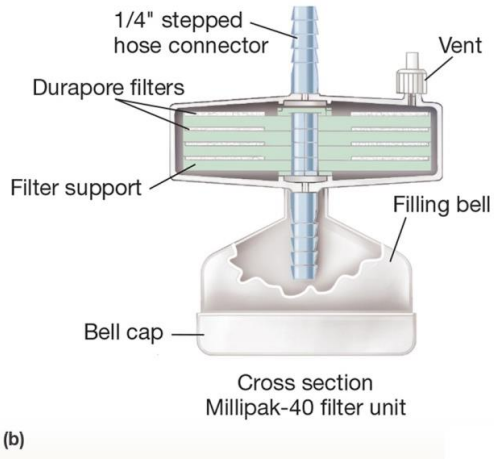
Mechanical removal methods
Filtration

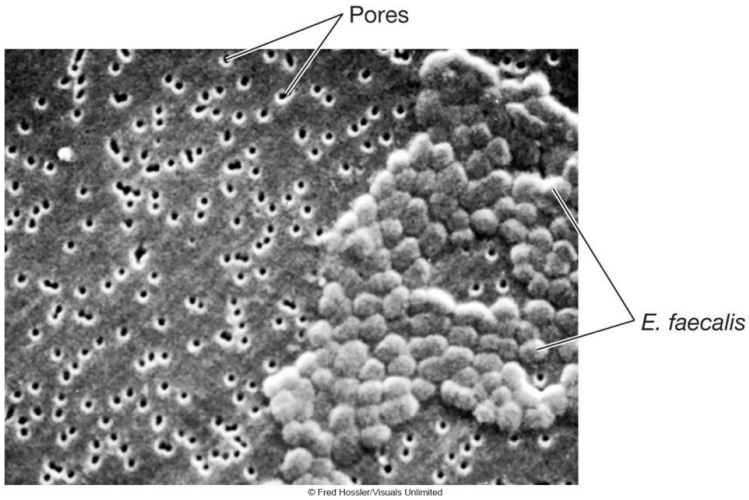
- Reduces microbial population or sterilizes solutions of heat-sensitive materials by removing microorganisms
- Also used to reduce microbial populations in air

Filtering Liquids

- Membrane filters
  - porous membranes with defined pore sizes that remove microorganisms primarily by physical screening



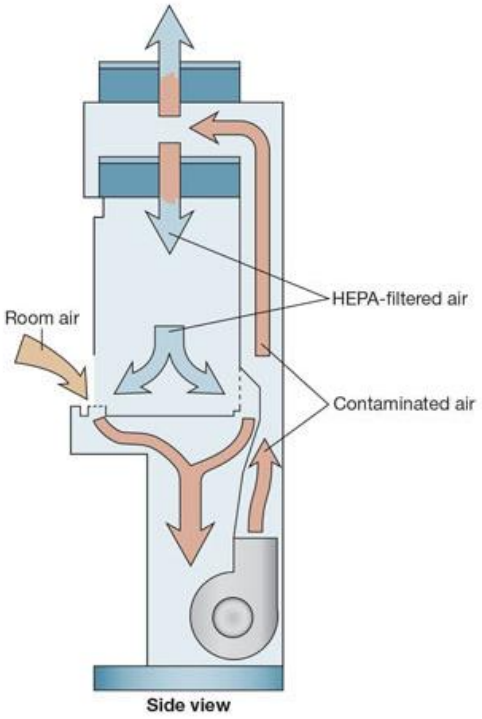




Filtering Air

- Surgical masks
- High-efficiency particulate air (HEPA) filters
  - used in laminar flow biological safety cabinets

(a)



(b)

Osmotic Effects on Microbial Growth

- ***Water activity (a_w)***: A physical term used by microbiologist to express quantitatively the degree of water availability
  - Defined as ratio of vapor pressure of air in equilibrium with a substance or solution to the vapor pressure of pure water
  - ***(a_w)= P solution/P water***

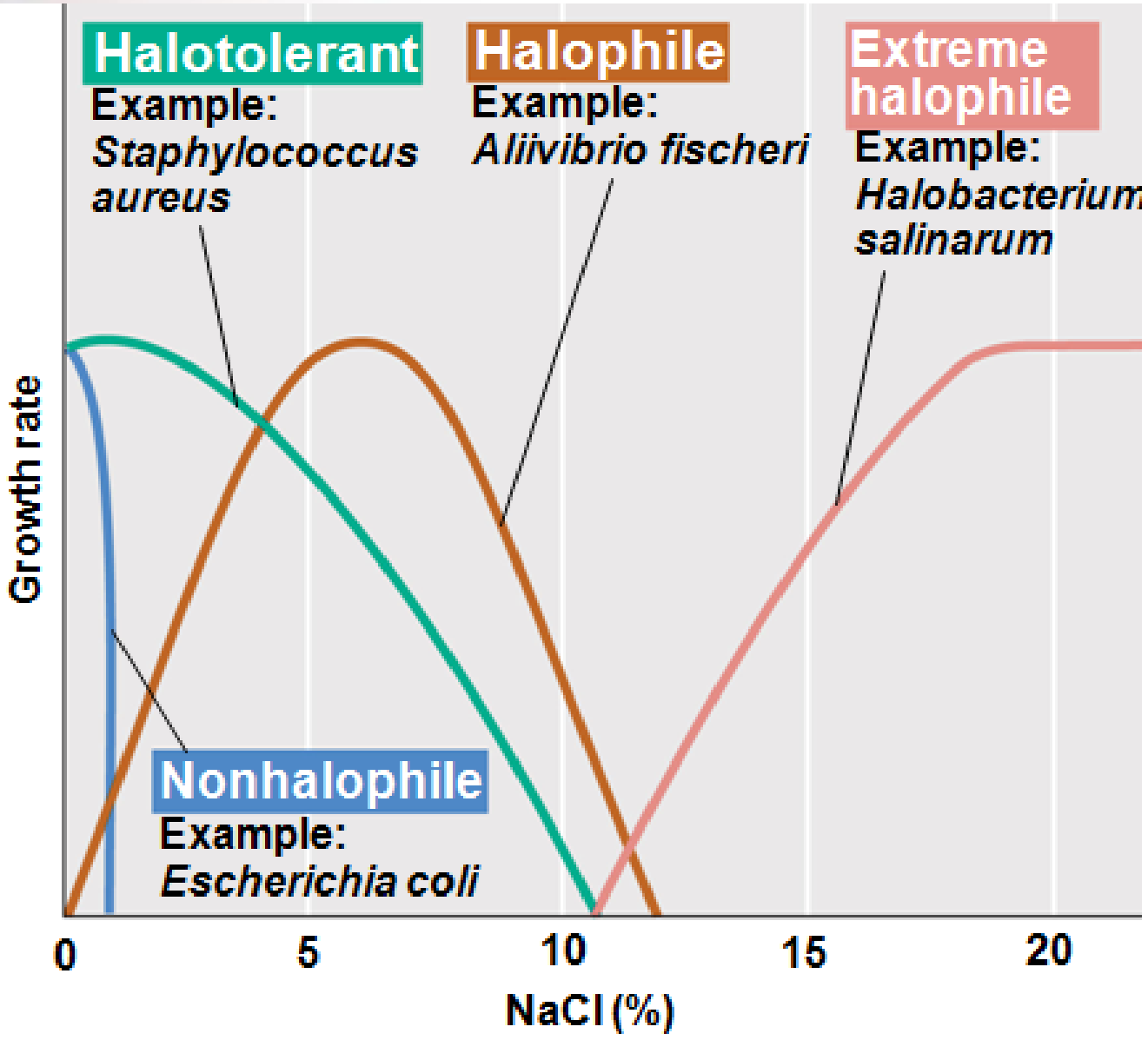
Water activity of several substances

Water activity (a_w)	Material	Example organisms[a]
1.000	Pure water	*Caulobacter, Spirillum*
0.995	Human blood	*Streptococcus, Escherichia*
0.980	Seawater	*Pseudomonas, Vibrio*
0.950	Bread	Most gram-positive rods
0.900	Maple syrup, ham	Gram-positive cocci such as *Staphylococcus*
0.850	Salami	*Saccharomyces rouxii* (yeast)
0.800	Fruit cake, jams	*Saccharomyces bailii, Penicillium* (fungus)
0.750	Salt lakes, salted fish	*Halobacterium, Halococcus*
0.700	Cereals, candy, dried fruit	*Xeromyces bisporus* and other xerophilic fungi

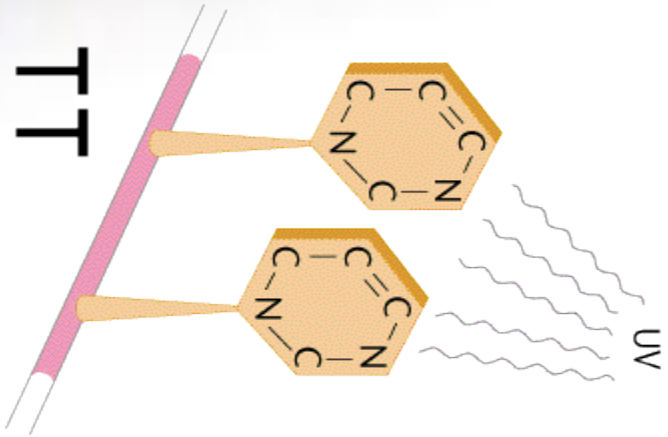
Environmental factors that influence growth

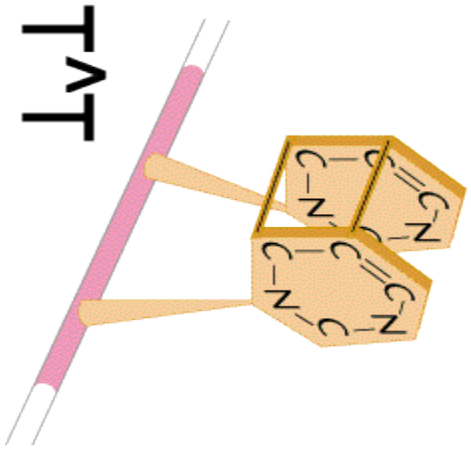
- **Water**: water moves from low to high solute. Osmotic effect.
- ***Halophiles***: organisms that require the presence of NaCl or other salts at a concentration above 0.2 M
- ***Extreme halophiles***: organisms that require high levels (15–30%) of NaCl for growth- sea salt 3% - *Halobacterium* in the Dead Sea)
- ***Halotolerant***: organisms that can tolerate some reduction in water activity of environment but generally grow best in the absence of the added solute

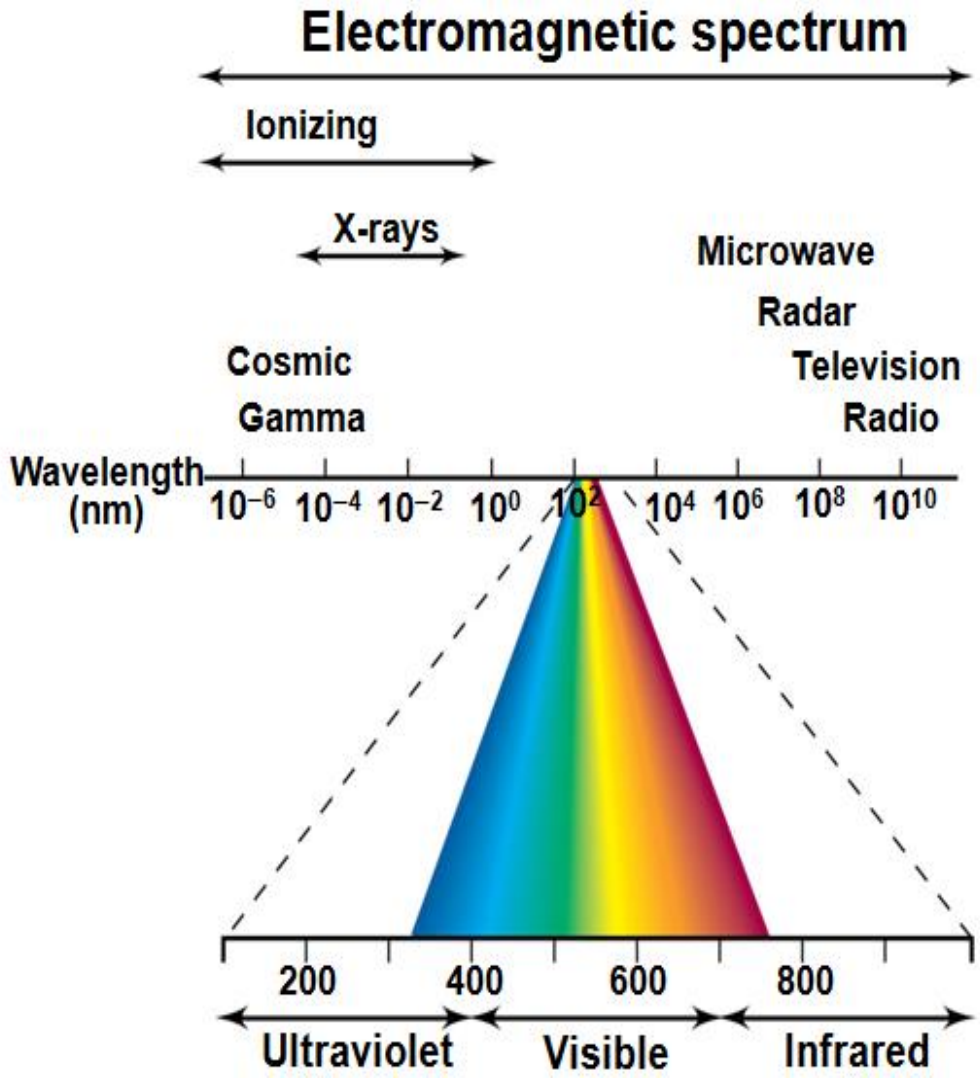
Effect of sodium chloride (NaCl) concentration on growth of microorganisms of different salt tolerances or requirements



UV radiation





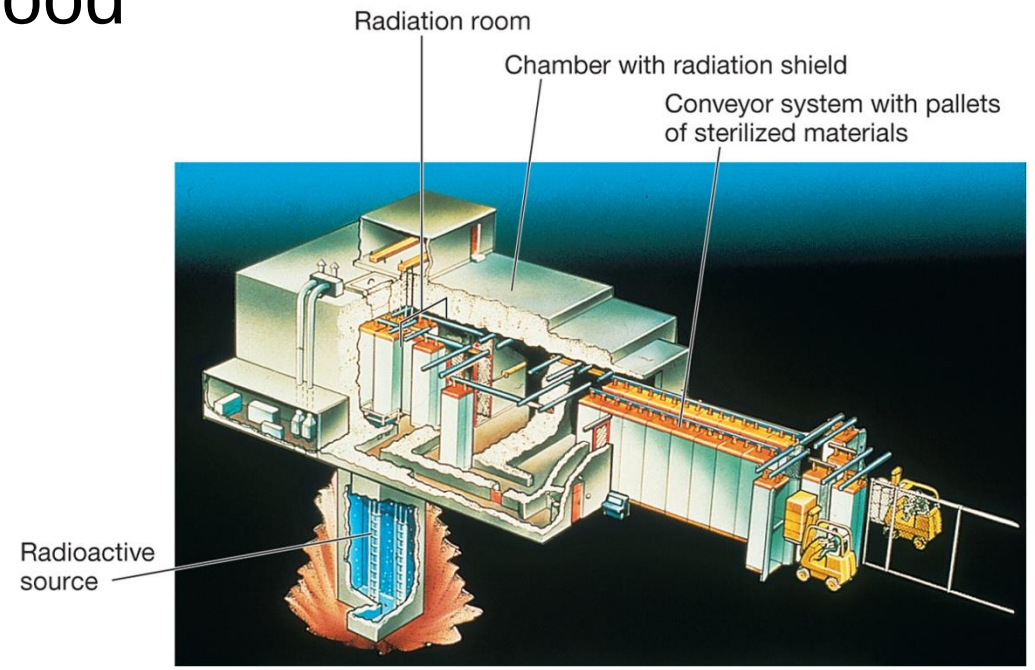


Ultraviolet (UV) Radiation

- Wavelength **of 260** is most bactericidal (DNA absorbs)
- Causes thymine dimers preventing replication and transcription
- **UV limited to surface sterilization because it does not penetrate glass, dirt films, water, and other substances**
- Has been used for water treatment

Ionizing Radiation

- Gamma radiation penetrates deep into objects
- Destroys bacterial endospores; not always effective against viruses
- Used for sterilization and pasteurization of antibiotics, hormones, sutures, plastic disposable supplies, and food



To do

Temperature	*subtilis Bacillus*		*Escherichia coli*	
	30 mins	60 mins	30 mins	60 mins
5° C				
RT				
37° C				
55° C				
70° C				
90° C				

Radiation

Time	
1 second	
5 second	
10 second	
30 second	
45 second	
50 second	
60 second	
Lid on	

Salt concentration	5%NaCl	10%NaCl	15% NaCl