

Microbial Growth

Environmental Forcing Functions:

- Temperature: Psychrophile, Mesophile, Thermophile, & Hyperthermophile
Cardinal Temps: Min*, Max, & Optimal*
Q₁₀ Rule: 10°C rise will double the growth rate*
- Pressure: Barophiles (Most are also psychrophiles!)
Found only in the deep ocean.....so far

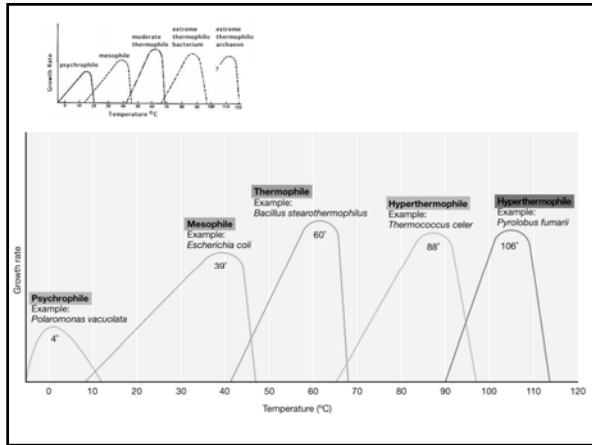
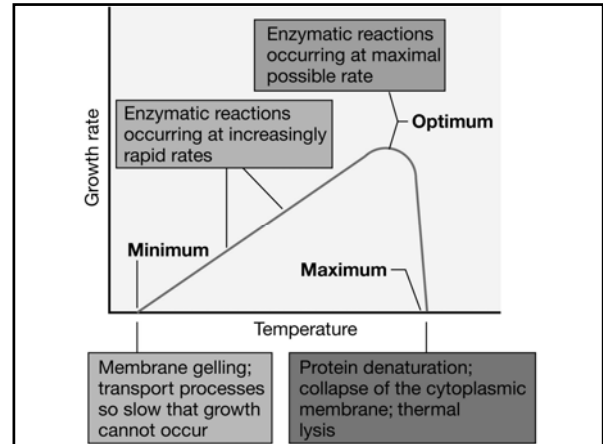
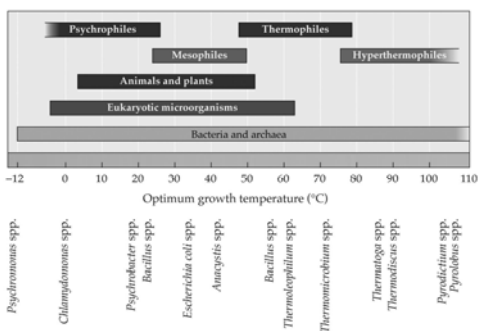
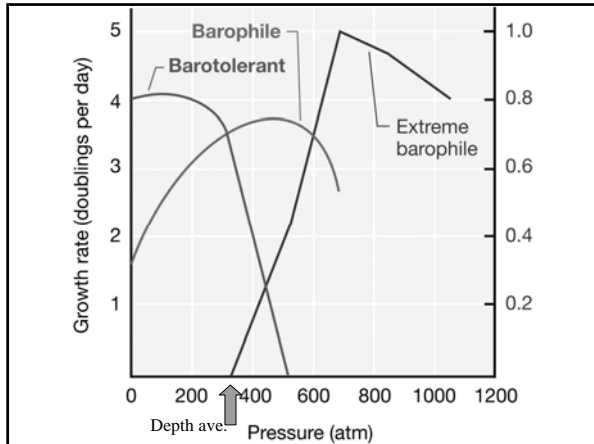


Table 6.3 Temperature ranges for growth of Bacteria and Archaea

Species	Range (°C)
Psychrophiles	
<i>Cytophaga psychrophila</i>	4–20
<i>Bacillus insolitus</i>	-0–25
<i>Aquaspirillum psychrophilum</i>	2–26
Mesophiles	
<i>Escherichia coli</i>	10–40
<i>Lactobacillus lactis</i>	18–42
<i>Bacillus subtilis</i>	22–40
<i>Pseudomonas fluorescens</i>	4–40
Thermophiles	
<i>Bacillus thermovorans</i>	42–75
<i>Thermoplasma album</i>	45–70
<i>Thermus aquaticus</i>	40–79
<i>Chloroflexus aurantiacus</i>	45–70
Hyperthermophiles (Archaea)	
<i>Hyperthermus butylicus</i>	85–108
<i>Methanothermobacter ferredoxinus</i>	65–97
<i>Pyrodicticum occultum</i>	80–110
<i>Thermococcus celer</i>	70–95

Growth temperature ranges for various life forms



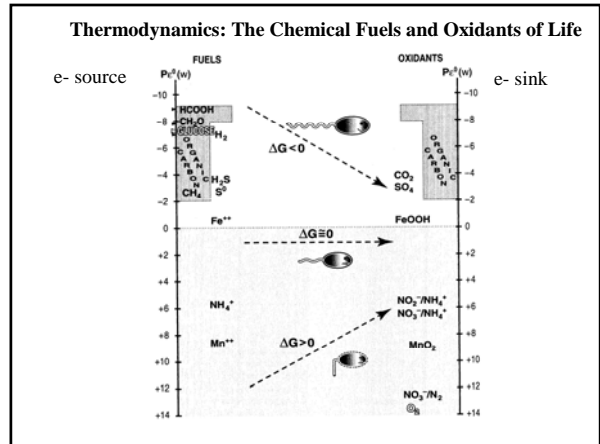
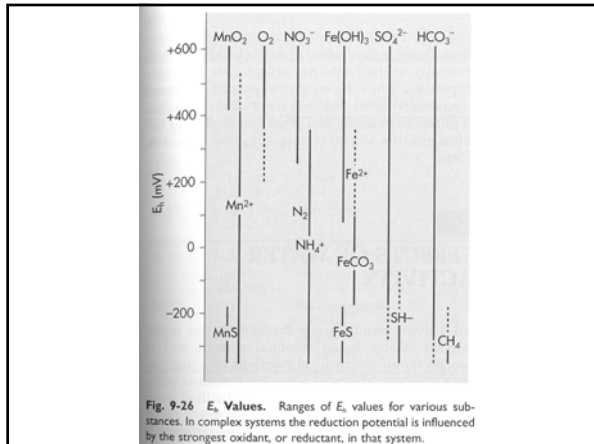
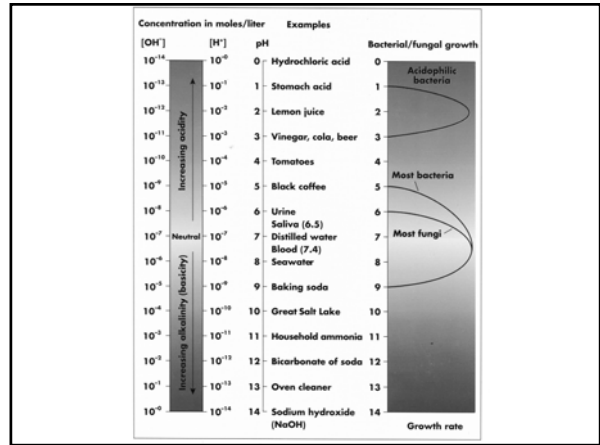


Microbial Growth

Environmental Forcing Functions:

- pH: acidophiles & alkaliphiles
cytoplasm still near neutral
- eH: available electron donors & terminal electron acceptors
affects the chemistry of the environment

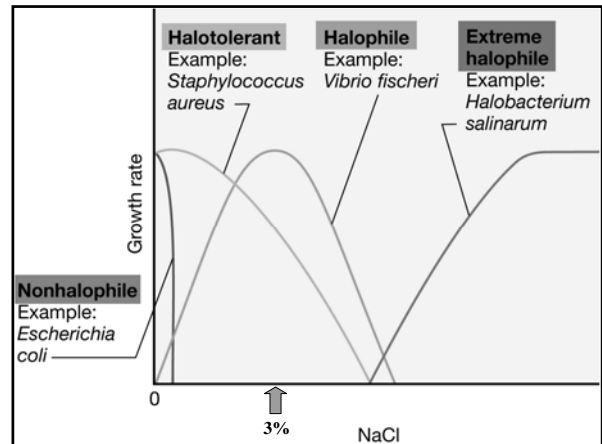
	pH	Example	Moles per liter of:	
			H ⁺	OH ⁻
Acidophiles Increasing acidity	0		1	10 ⁻¹⁴
	1	Volcanic soils, waters Gastric fluids Lemon juice	10 ⁻¹	10 ⁻¹³
	2	Acid mine drainage Vinegar Rhubarb Peaches	10 ⁻²	10 ⁻¹²
	3		10 ⁻³	10 ⁻¹¹
	4	Acid soil Tomatoes	10 ⁻⁴	10 ⁻¹⁰
	5	American cheese Cabbage	10 ⁻⁵	10 ⁻⁹
	6	Peas Corn, salmon, shrimp	10 ⁻⁶	10 ⁻⁸
	7	Pure water	10 ⁻⁷	10 ⁻⁷
	8	Seawater	10 ⁻⁸	10 ⁻⁶
	9	Very alkaline natural soil	10 ⁻⁹	10 ⁻⁵
Alkaliphiles Increasing alkalinity	10	Alkaline lakes Soap solutions	10 ⁻¹⁰	10 ⁻⁴
	11	Household ammonia Extremely alkaline soda lakes	10 ⁻¹¹	10 ⁻³
	12	Lime (saturated solution)	10 ⁻¹²	10 ⁻²
	13		10 ⁻¹³	10 ⁻¹
	14		10 ⁻¹⁴	1



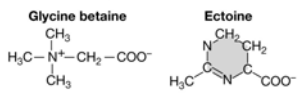
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Environmental Forcing Functions:

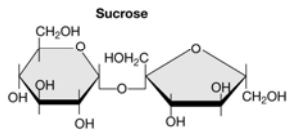
- Salt: Halophiles
Compatible solutes: amino acid derivatives (e.g., proline & glycine)
- Water Activity: Xerophiles (live in very dry habitats)
All microbes are **osmotrophs**, must use organic material in solution!
- Oxygen Usage: aerobic, facultative (an)aerobe, microaerophile, obligate anaerobe
DeTox enzymes: Catalase, Peroxidase, SOD



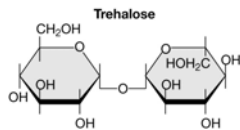
1. Amino acid-type solutes:



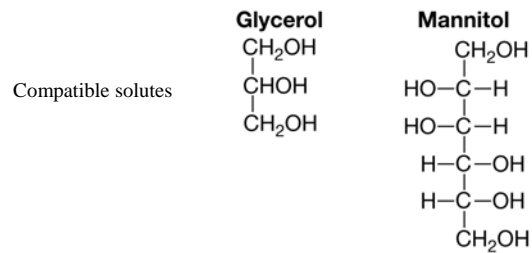
2. Carbohydrate-type solutes:



Compatible solutes



3. Alcohol-type solutes:



4. Other:

Dimethylsulfoniopropionate:

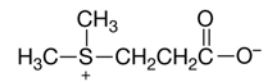
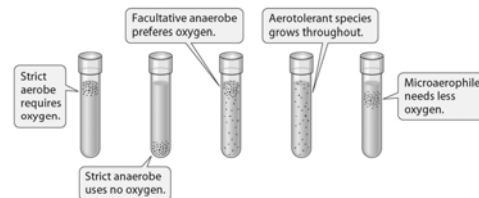


Table 6.4 Tolerance of selected *Bacteria* and *Archaea* for decreased water activity a_w

Type	Organisms	a_w
Nonhalophiles	<i>Aquaspirillum</i> and <i>Caulobacter</i>	1.00
Marine forms	<i>Pseudomonads</i> and <i>Alteromonas</i>	0.98
Moderate halophiles	<i>Vibrio</i> species and gram-positive cocci	0.91
Extreme halophiles	<i>Halobacterium</i> and <i>Halococcus</i>	0.75

MICROBIAL LIFE, Table 6.4 © 2002 Sinauer Associates, Inc.

Response of bacterial growth to oxygen availability



MICROBIAL LIFE, Figure 8.11 © 2002 Sinauer Associates, Inc.

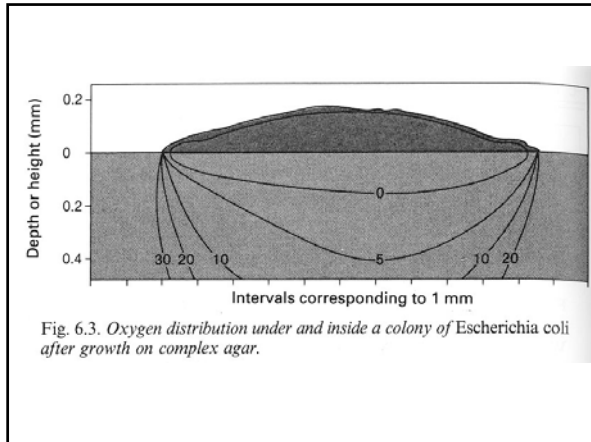


Table 9-5 Electronic States of Oxygen

Form	Formula	Simplified Electronic Structure	Spin of Outer Electrons
Triplet oxygen (normal atmospheric form)	$^3\text{O}_2$	$\dot{\text{O}}-\dot{\text{O}}$	$\uparrow \uparrow$
Singlet oxygen	$^1\text{O}_2$	$\dot{\text{O}}-\dot{\text{O}}$	$\downarrow \uparrow$
Nasty!			$\uparrow \downarrow$
Superoxide free radical	O_2^-	$\ddot{\text{O}}-\dot{\text{O}}$	$\downarrow \uparrow$
Peroxide	O_2^{2-}	$\ddot{\text{O}}-\ddot{\text{O}}$	$\downarrow \downarrow$

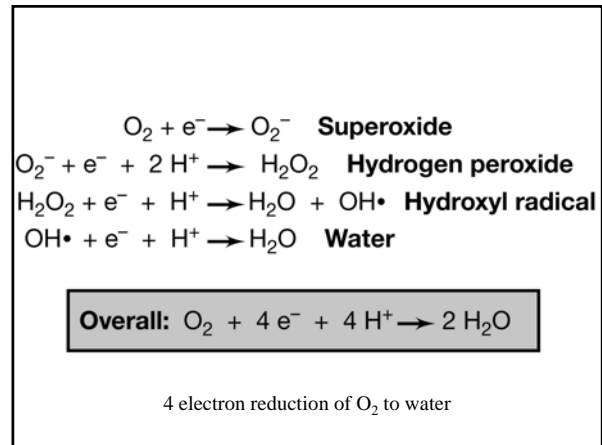
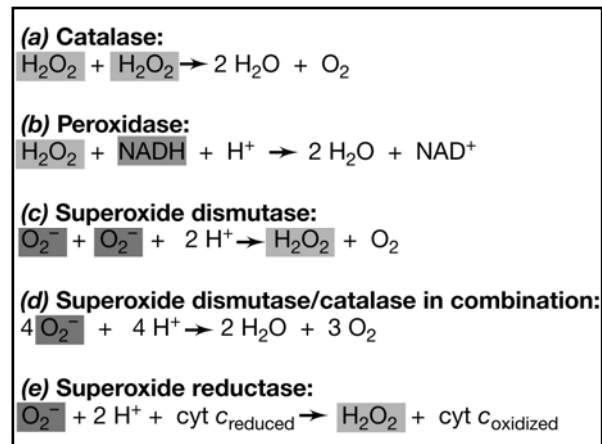
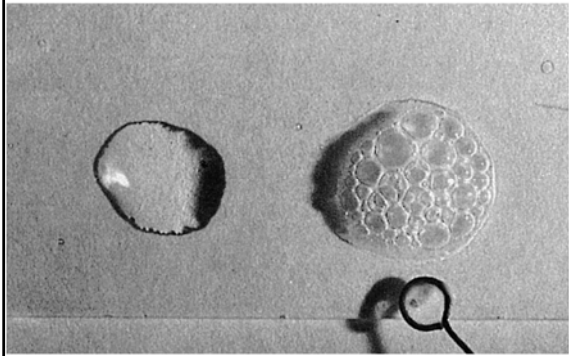


Table 9-6 Bacterial Enzymes that Protect the Cell Against Toxic Forms of Oxygen

Microorganism	Catalase	Superoxide Dismutase
Aerobe	+	+
Facultative anaerobe	+	+
Microaerophile	-	+
Obligate anaerobe	-	-



Catalase Test



T. D. Brock

Cytochrome Oxidase Test

An important diagnostic indicator for the identification of *Pseudomonas* and *Neisseria* spp.



Oxidase Test

