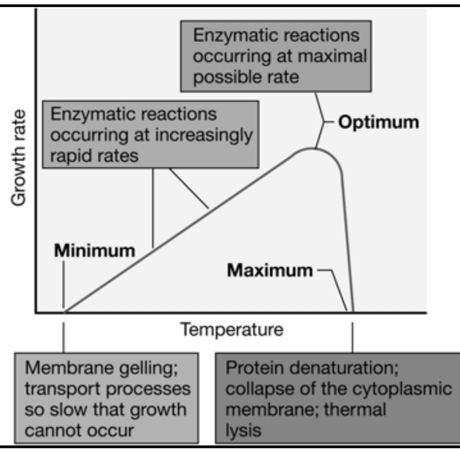
Microbial Growth

Environmental Forcing Functions:

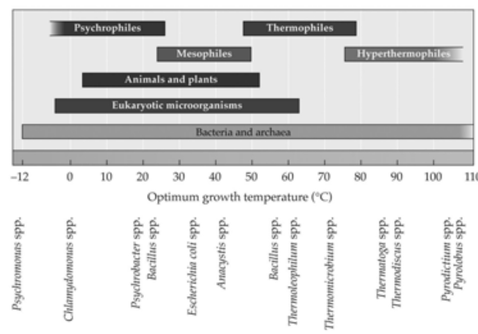
- Temperature: Psychrophile, Mesophile, Thermophile, & Hyperthermophile
  - Cardinal Temps: Min*, Max, & Optimal*
  - Q_{10} Rule: 10°C rise will double the growth rate*
- Pressure: Barophiles (Most are also psychrophiles!)
  - Found only in the deep ocean.....so far

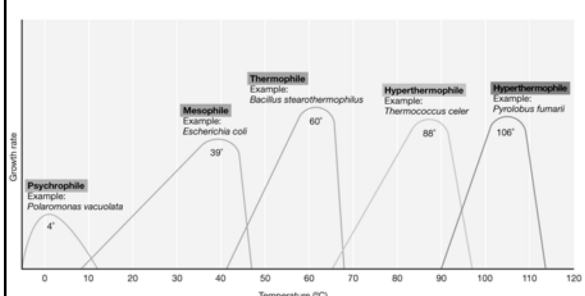
Table 6.3 Temperature ranges for growth of *Bacteria* and *Archaea*

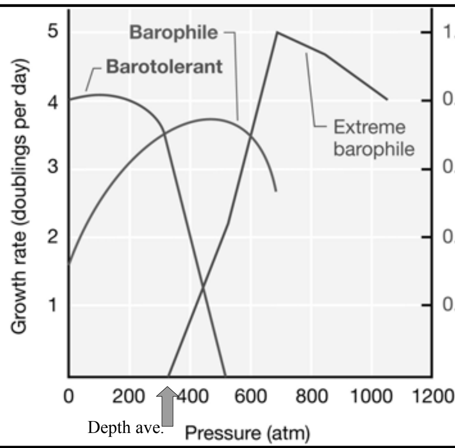
Species	Range (°C)
Psychrophiles	
Cytophaga psychrophila	4–20
Bacillus insolitus	<0–25
Aquaspirillum psychrophilum	2–26
Mesophiles	
Escherichia coli	10–40
Lactobacillus lactis	18–42
Bacillus subtilis	22–40
Pseudomonas fluorescens	4–40
Thermophiles	
Bacillus thermoleovorans	42–75
Thermoleophilum album	45–70
Thermus aquaticus	40–79
Chloroflexus aurantiacus	45–70
Hyperthermophiles (*Archaea*)	
Hyperthermus butylicus	85–108
Methanothermus fervidus	65–97
Pyrodictium occultum	80–110
Thermococcus celer	70–95

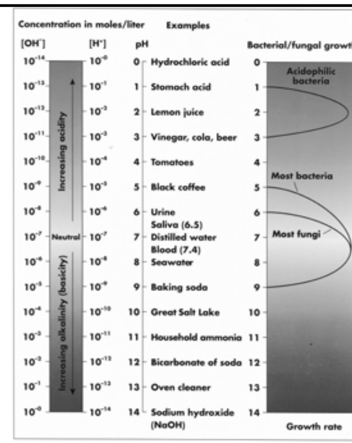


Growth temperature ranges for various life forms









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

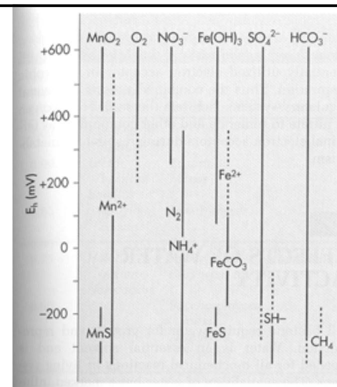
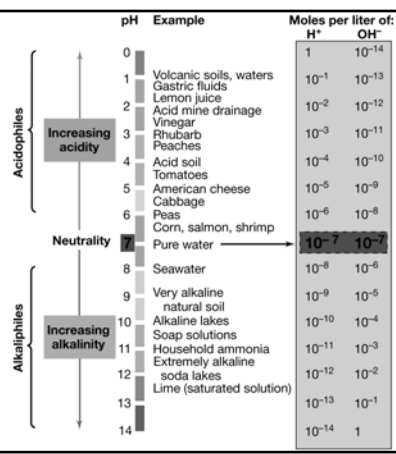
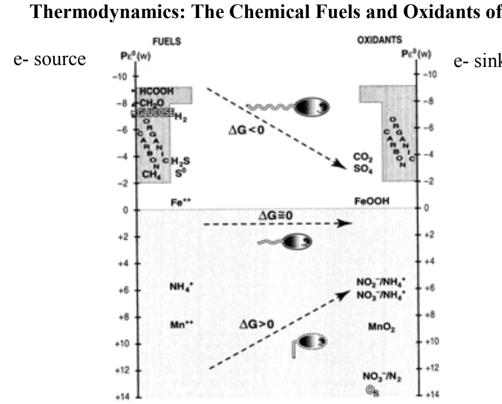


Fig. 9-26 *E_h* **Values.** Ranges of E_h values for various substances. In complex systems the reduction potential is influenced by the strongest oxidant, or reductant, in that system.



Thermodynamics: The Chemical Fuels and Oxidants of Life



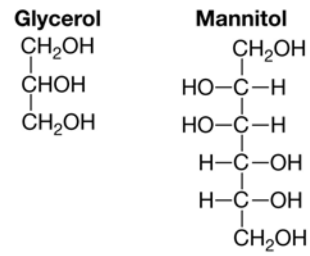
Microbial Growth

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: aerobe, facultative (an)aerobe, microaerophile, obligate anaerobe
  DeTox enzymes: Catalase, Peroxidase, SOD

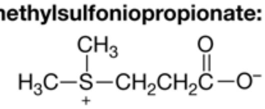
3. Alcohol-type solutes:

Compatible solutes



4. Other:

Dimethylsulfoniopropionate:



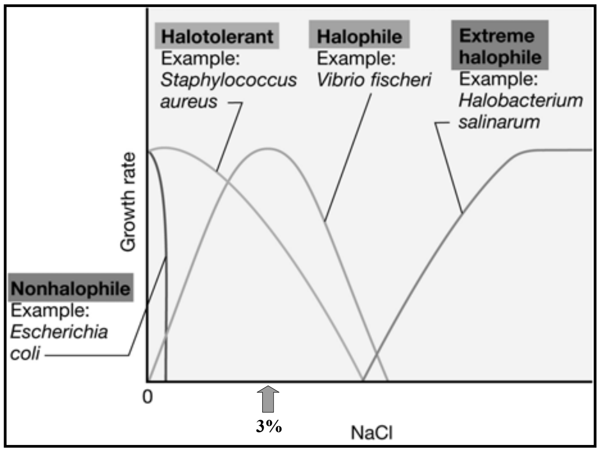
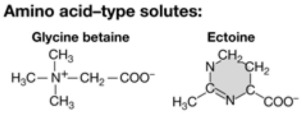


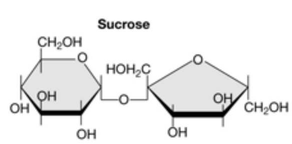
Table 6.4 Tolerance of selected *Bacteria* and *Archaea* for decreased water activity a_w

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

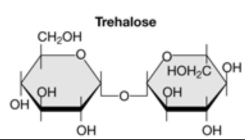
1. Amino acid–type solutes:



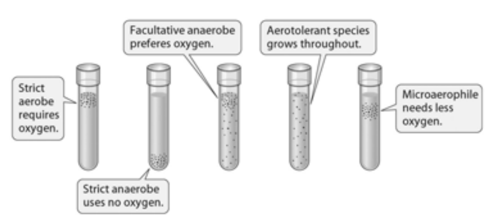
2. Carbohydrate-type solutes:



Compatible solutes



Response of bacterial growth to oxygen availability



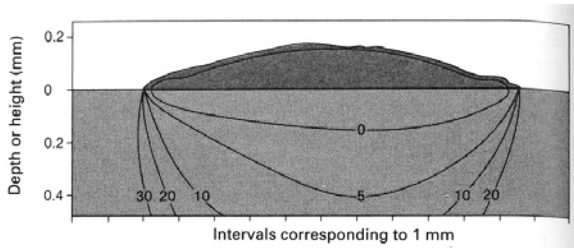


Fig. 6.3. *Oxygen distribution under and inside a colony of* Escherichia coli *after growth on complex agar.*

$O_2 + e^- \rightarrow O_2^-$ **Superoxide**

$O_2^- + e^- + 2H^+ \rightarrow H_2O_2$ **Hydrogen peroxide**

$H_2O_2 + e^- + H^+ \rightarrow H_2O + OH\bullet$ **Hydroxyl radical**

$OH\bullet + e^- + H^+ \rightarrow H_2O$ **Water**

Overall: $O_2 + 4e^- + 4H^+ \rightarrow 2H_2O$

4 electron reduction of O_2 to water

(a)

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

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

Table 9-5 Electronic States of Oxygen

Form	Formula	Simplified Electronic Structure	Spin of Outer Electrons	
Triplet oxygen (normal atmospheric form)	$^3O_2$	Ȯ—Ȯ	(↑)	(↑)
Singlet oxygen	$^1O_2$	Ȯ—Ȯ	(↓↑)	( )
⇧ **Nasty!**			(↑)	(↓)
Superoxide free radical	O_2^-	Ö—Ȯ	(↓↑)	(↑)
Peroxide	O_2^{2-}	Ö—Ö	(↓↑)	(↓↑)

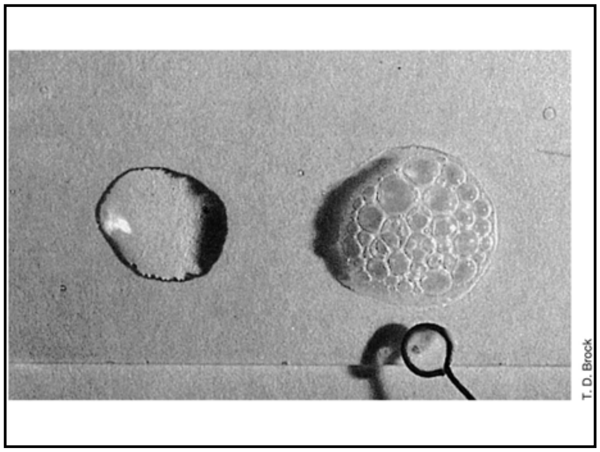
(a) **Catalase:**
$H_2O_2 + H_2O_2 \rightarrow 2H_2O + O_2$

(b) **Peroxidase:**
$H_2O_2 + NADH + H^+ \rightarrow 2H_2O + NAD^+$

(c) **Superoxide dismutase:**
$O_2^- + O_2^- + 2H^+ \rightarrow H_2O_2 + O_2$

(d) **Superoxide dismutase/catalase in combination:**
$4O_2^- + 4H^+ \rightarrow 2H_2O + 3O_2$

(e) **Superoxide reductase:**
$O_2^- + 2H^+ + \text{cyt } c_{reduced} \rightarrow H_2O_2 + \text{cyt } c_{oxidized}$


T. D. Brock