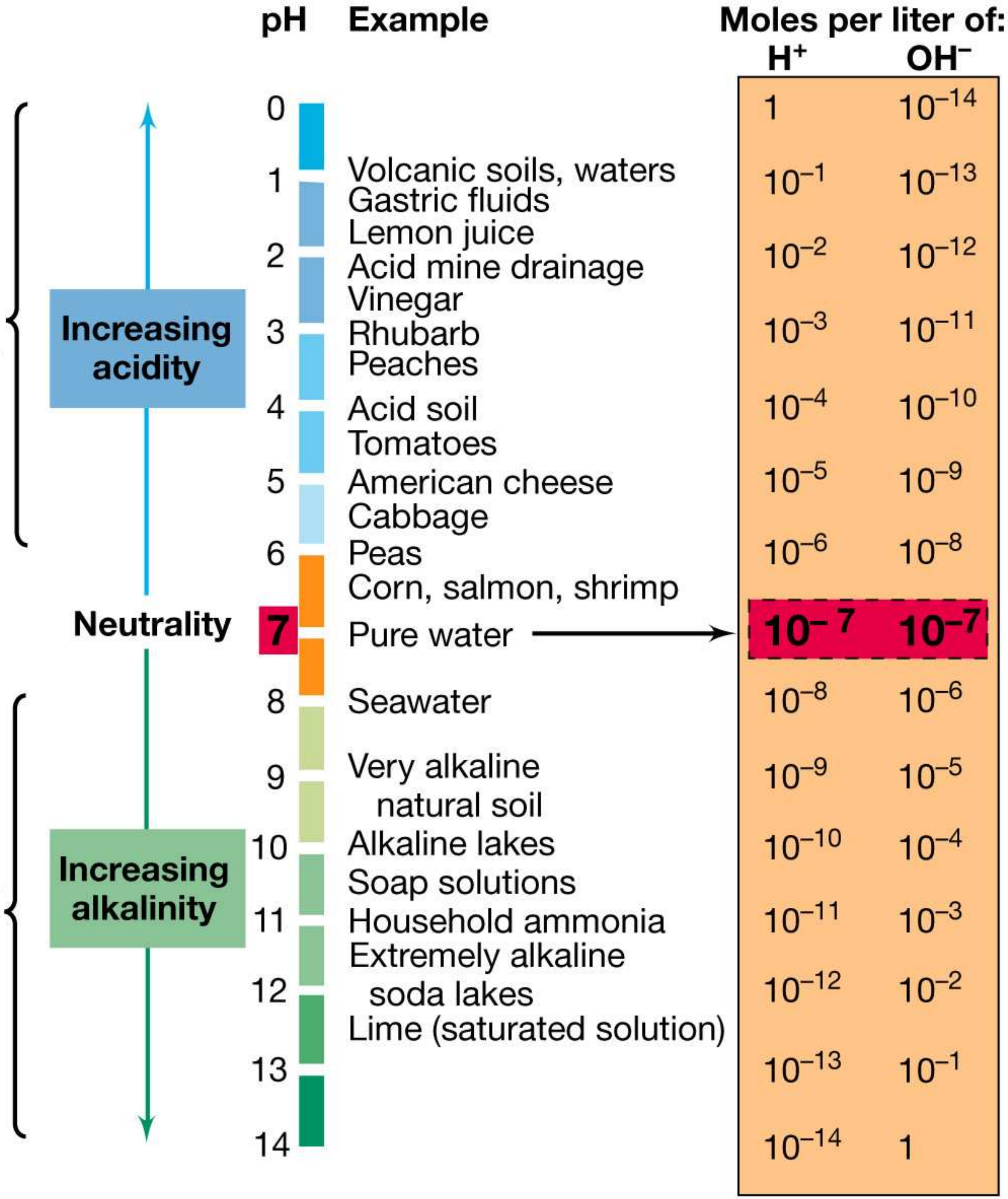
MICROBIOLOGIA GENERALE

Microbial growth 2

Acidophiles

Neutrophiles

Alkaliphiles

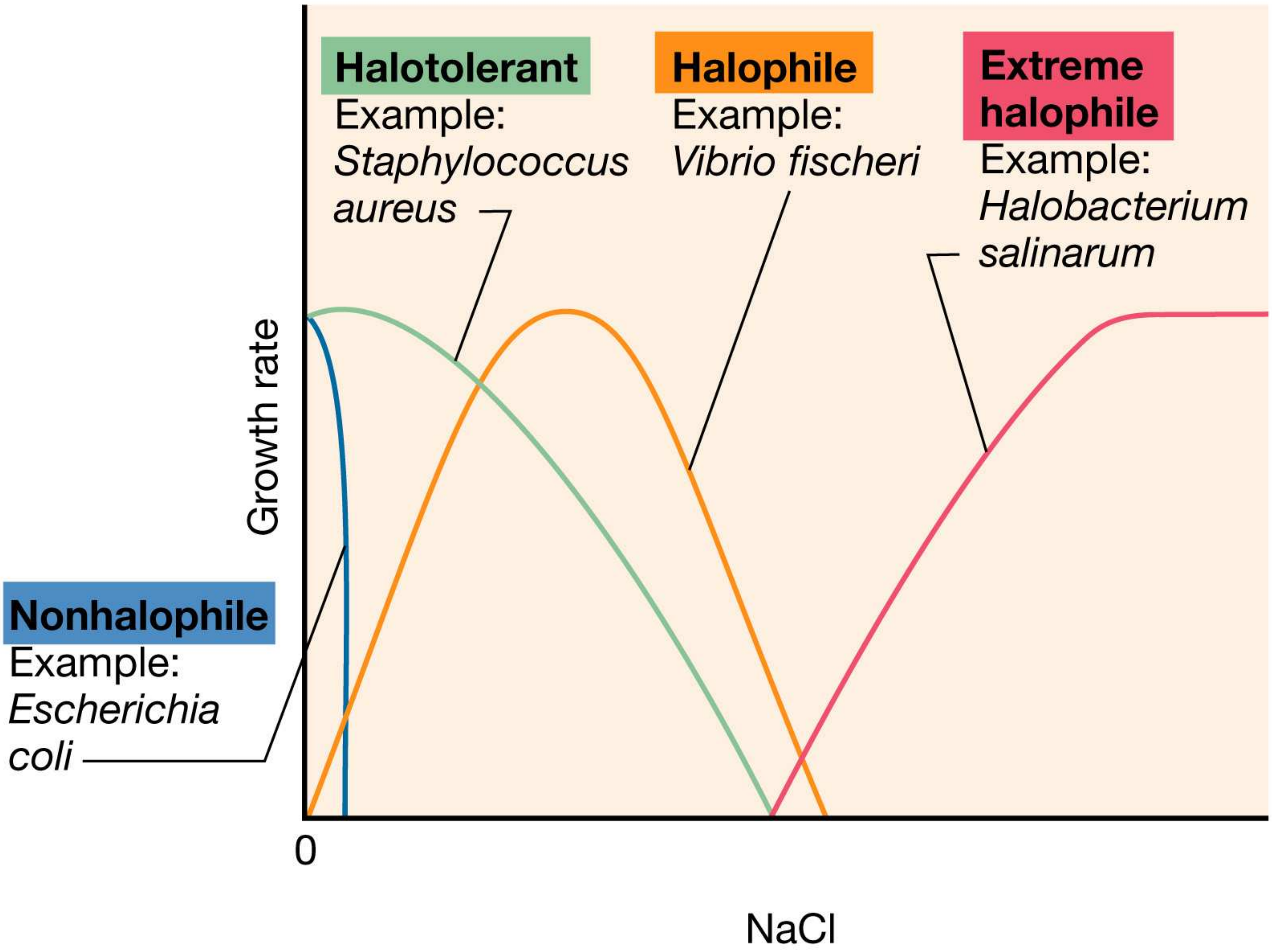


pH range of some microorganisms

Microorganisms	Minimum	Maximum	Acid-fastness
Micrococcus sp	**5.6**	**8.1**	**Low acid-fastness minimum >5.0**
Pseudomonas aeruginosa	**5.6**	**8.0**	
Bacillus stearothermophilus	**5.2**	**9.2**	
Clostridum sporogenes	**5.0**	**9.0**	**Intermediate acid-fastness minimum 5.0-4.0**
Bacillus cereus	**4.9**	**9.3**	
Vibrio parahaemolyticus	**4.8**	**11.0**	
Clostridum botulinum	**4.5**	**8.5**	
Staphylococcus aureus	**4.0**	**9.8**	
Salmonella sp	**4,0-4.5**	**8-9.6**	
Escherichia coli	**4,4**	**9.0**	
Lactic Acid Bacteria	**3,8 Ğ4.4**	**7.2**	**High acid-fastness minimum 4.0**
Acetic Acid Bacteria	**2.6**	**4.3**	
Yeasts	**2.3**	**8.6**	
Molds	**1.6-1.9**	**9.3**	

Microbial growth:

osmotic effects on growth



Halotolerant
Example:
Staphylococcus
aureus
Halophile
Example:
Vibrio fischeri
Extreme
halophile
Example:
Halobacterium
salinarum
Nonhalophile
Example:
Escherichia
coli
Growth rate
0
NaCl

Water activity of several substances

Water activity (a_w)	Material	Example
1.000	Pure water	Spirillum
0.995	Human blood	*Streptococcus*
0.980	Seawater	*Vibrio*
0.950	Bread	Gram + rods
0.900	Ham	*Staphylococcus*
0.850	Salami	*Saccharomyces rouxii* (yeast)
0.800	Fruit cakes, jams	*Saccharomyces bailii* (fungus)
0.750	Salt lakes, salted fish	*Halobacterium*
0.700	Cereals, candy, dried fruit	Xerophilic fungi

Water activity (a_w) and microbial growth

a_w	Bacteria	Yeasts	Molds
0.98-0.97	***Pseudomonas, Clostridium***		
0.96-0.95	***Salmonella, Enterobacteriaceae, Bacillus, Vibrio, Shigella***		
0.94-0.93	***Streptococcus, Lactobacillus***	***Rhodotorula***	***Rhizopus, Mucor***
0.91-0.90	***Micrococcus, Lactobacillus***	***Candida and other pathogens***	***Cladosporium***
0.86	***Staphylococcus***		
0.80		***Saccaromyces***	***Aspergillus pennicillium***
0.75	**Halophiles**		***Aspergillus flavus*** ***Aspergillus ochraceus***

Water activity and food preservation

Microbial growth can be controlled by lowering the available water content (a_w reduction) of foods by:

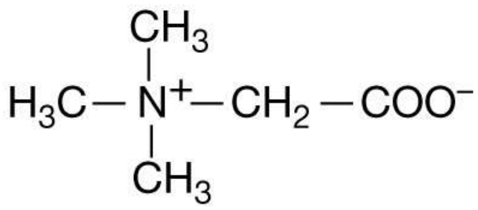
- Freezing
- Drying
- Lyophilization (freeze-drying)
- Addition of high concentrations of solutes such as sugars or salts

Tab. 6.3 Soluti compatibili nei microrganismi

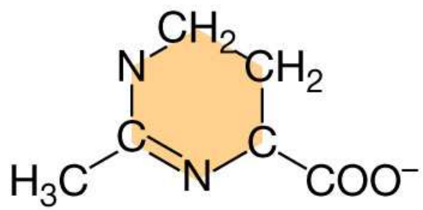
Organismo	Principale soluto accumulato	a_w minima per la crescita
Batteri, non fototrofi	Glicina betaina, prolina (principalmente Gram-positivi), glutamato (principalmente Gram-negativi)	0,97-0,90
Cianobatteri d'acqua fresca	Saccarosio, trealosio	0,98
Cianobatteri marini	α-glucosilglicerolo	0,92
Alghe marine	Mannitolo, vari glicosidi, prolina, dimetilsulfoniopropionato	0,92
Cianobatteri dei laghi salati	Glicina betaina	0,90-0,75
Batteri alofili anossigenici fototrofi (specie di *Hectothiorhodospira*/*Halorhodospira* e *Rhodospirillum*)	Glicina betaina, ectoina, trealosio	0,90-0,75
Archea estremamente alofili (per esempio *Halobacterium*) e alcuni Batteri (per esempio *Haloanaerobium*)	KCl	0,75
Dunaliella (alga verde alofila)	Glicerolo	0,75
Lieviti xerofili	Glicerolo	0,83-0,62
Funghi filamentosi xerofili	Glicerolo	0,72-0,61

1. Amino acid–type solutes:

Glycine betaine

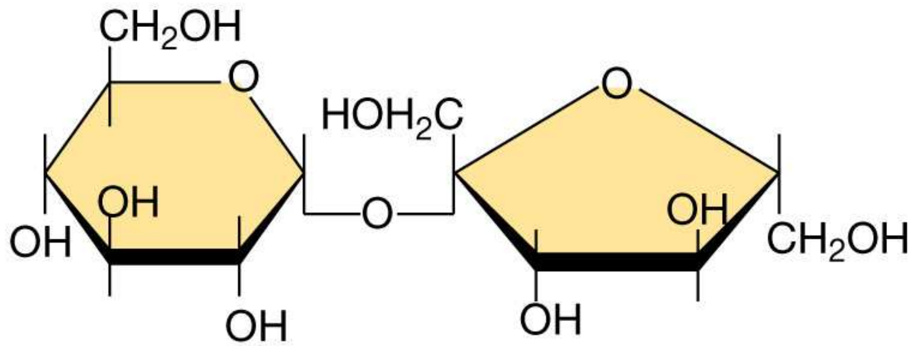


Ectoine

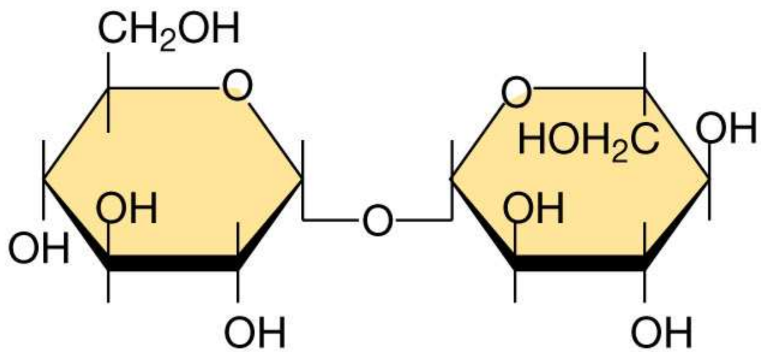


2. Carbohydrate-type solutes:

Sucrose



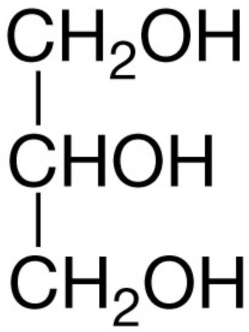
Trehalose



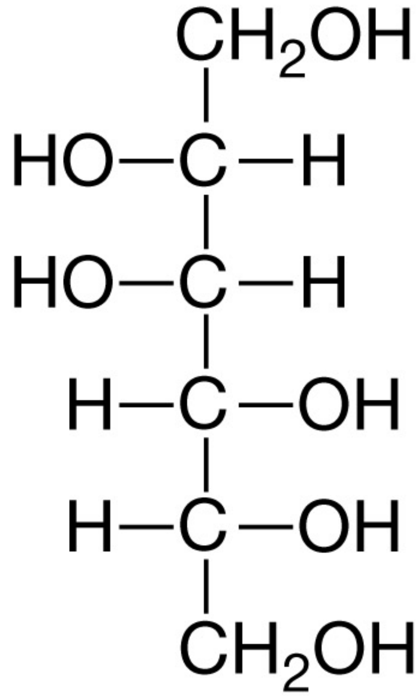
Structures of some common compatible solutes

3. Alcohol-type solutes:

Glycerol



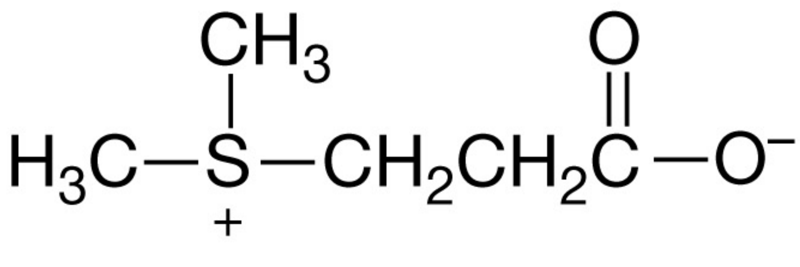
Mannitol



Structures of some common compatible solutes

4. Other:

Dimethylsulfoniopropionate:

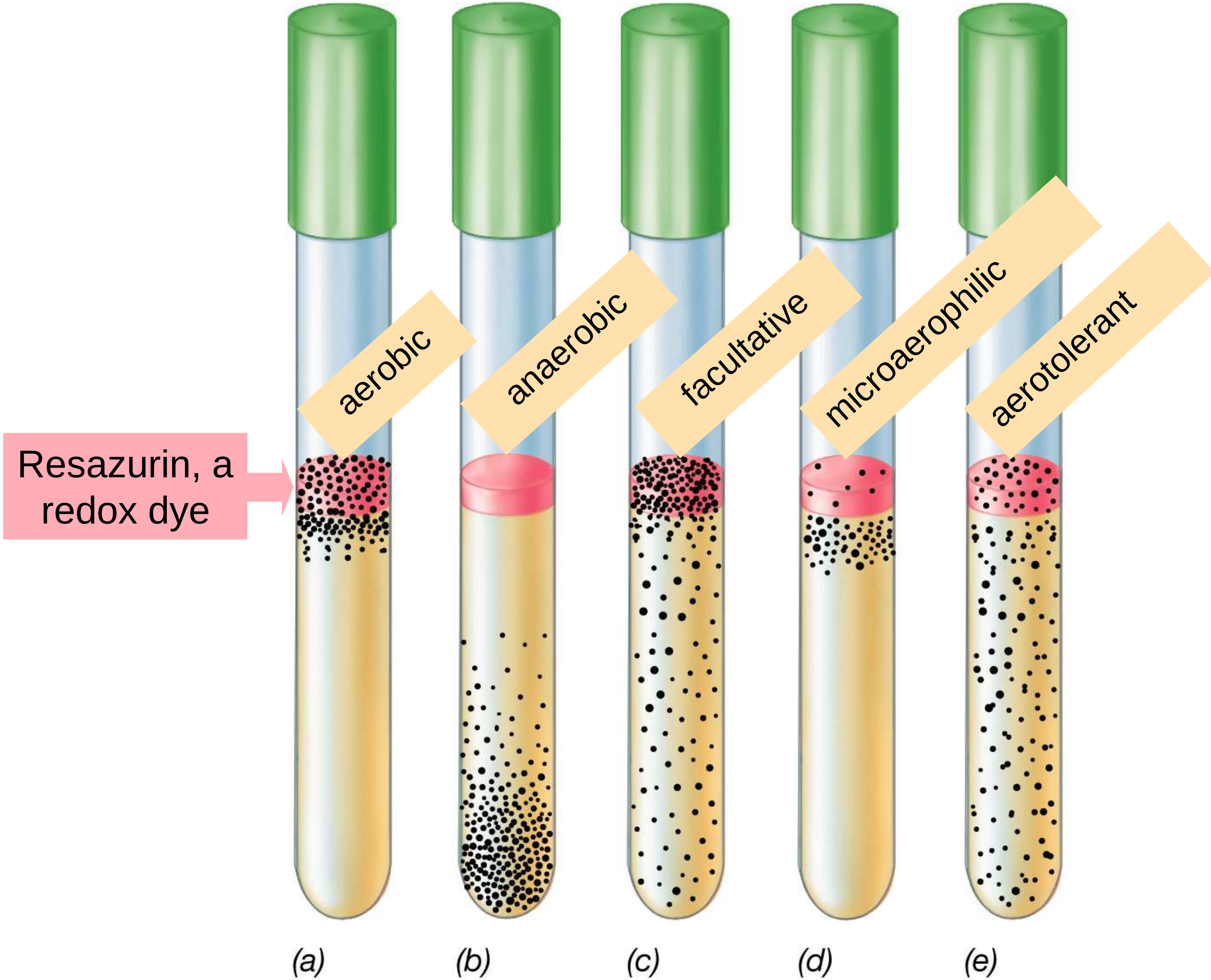


Microbial growth:

oxygen and growth

Oxygen classes of microorganisms

Group	Relationship to O_2	Type of metabolism	Example
AEROBES			
Obligate	Required	Aerobic respiration	*Micrococcus luteus*
Facultative	Not required, growth better with O2	Aerobic or Anaerobic respiration, Fermentation	*Escherichia coli*
Microaerophilic	Required at low levels	Aerobic respiration	*Spirillum volutans*
ANAEROBES			
Aerotolerant	Not required, growth no better with O2	Fermentation	*Streptococcus pyogenes*
Obligate	Harmful or lethal	Fermentation or Anaerobic respiration	*Clostridium tetani*


Resazurin, a redox dye
aerobic
anaerobic
facultative
microaerophilic
aerotolerant
(a)
(b)
(c)
(d)
(e)

Deborah O. Jung and M. T. Madigan

(a)


Coy Laboratory Products

(b)

Incubation under anoxic conditions

O. Jung and M. T. Madigan

Anoxic jar- A chemical reaction in the envelope in the jar generates H_2 + CO_2. The H_2 reacts with O_2 in the jar on the surface of a palladium catalyst to yield H_2O; the final atmosphere contains N_2, H_2, and CO_2.

Four-electron reduction of O_2 to water by stepwise addition of electrons. All the intermediates formed are reactive and toxic to cells except for water

$$O_2 + e^- \rightarrow O_2^- \quad \textbf{Superoxide}$$

$$O_2^- + e^- + 2H^+ \rightarrow H_2O_2 \quad \textbf{Hydrogen peroxide}$$

$$H_2O_2 + e^- + H^+ \rightarrow H_2O + OH\bullet \quad \textbf{Hydroxyl radical}$$

$$OH\bullet + e^- + H^+ \rightarrow H_2O \quad \textbf{Water}$$

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

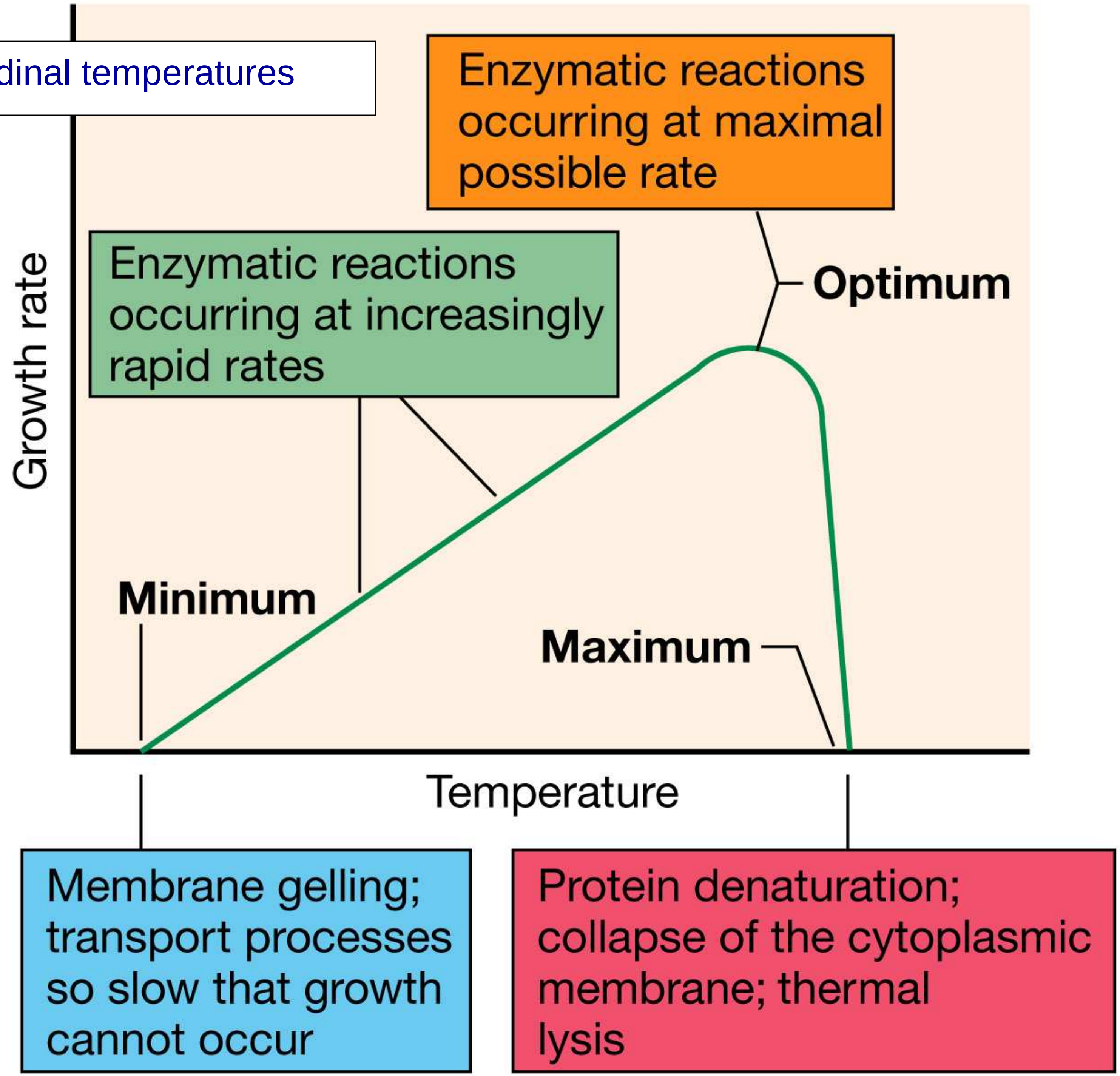
Microbial growth:

the effect of environmental factors on growth

Microbial growth:

the effect of temperature on growth

Cardinal temperatures

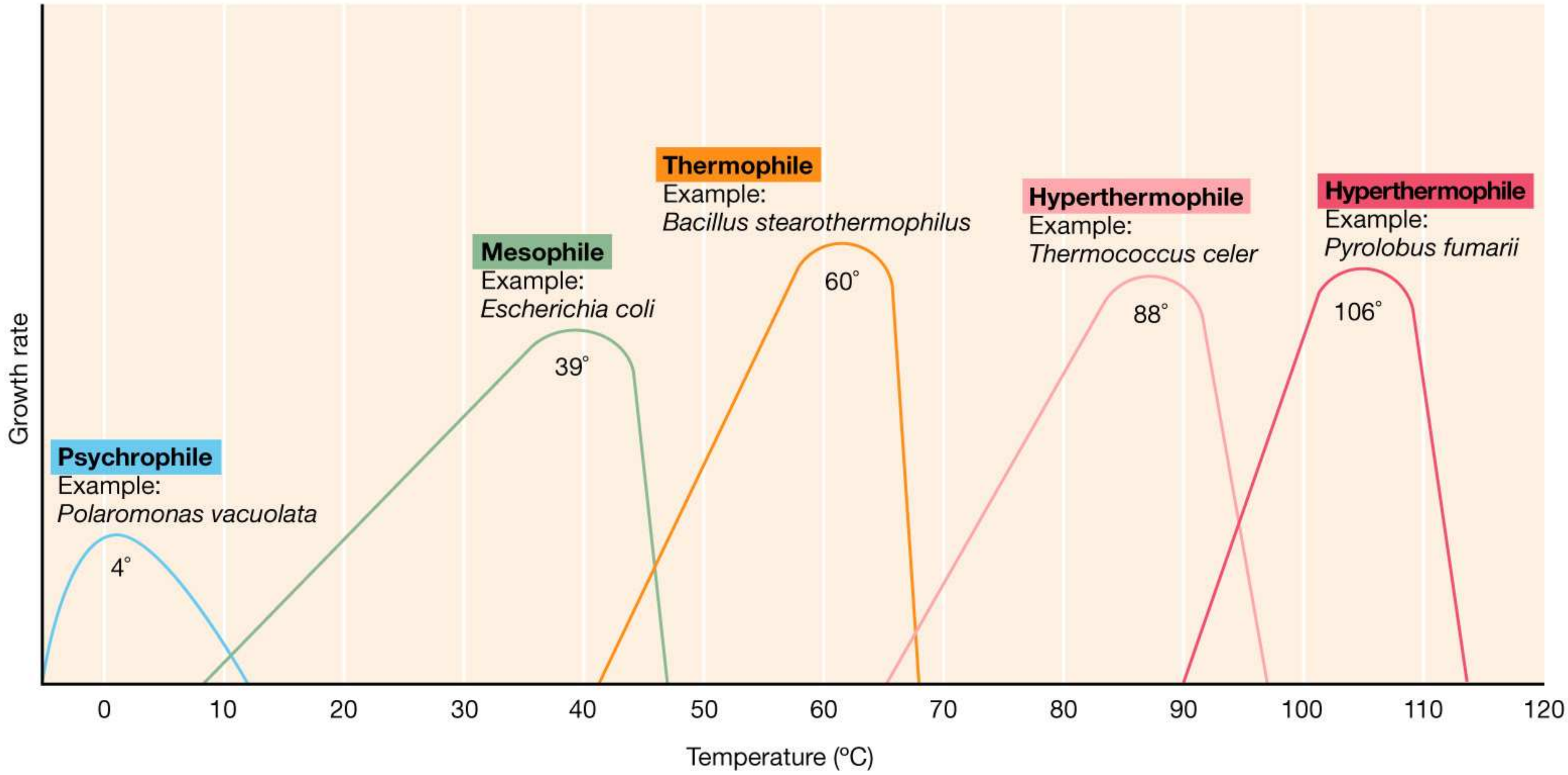


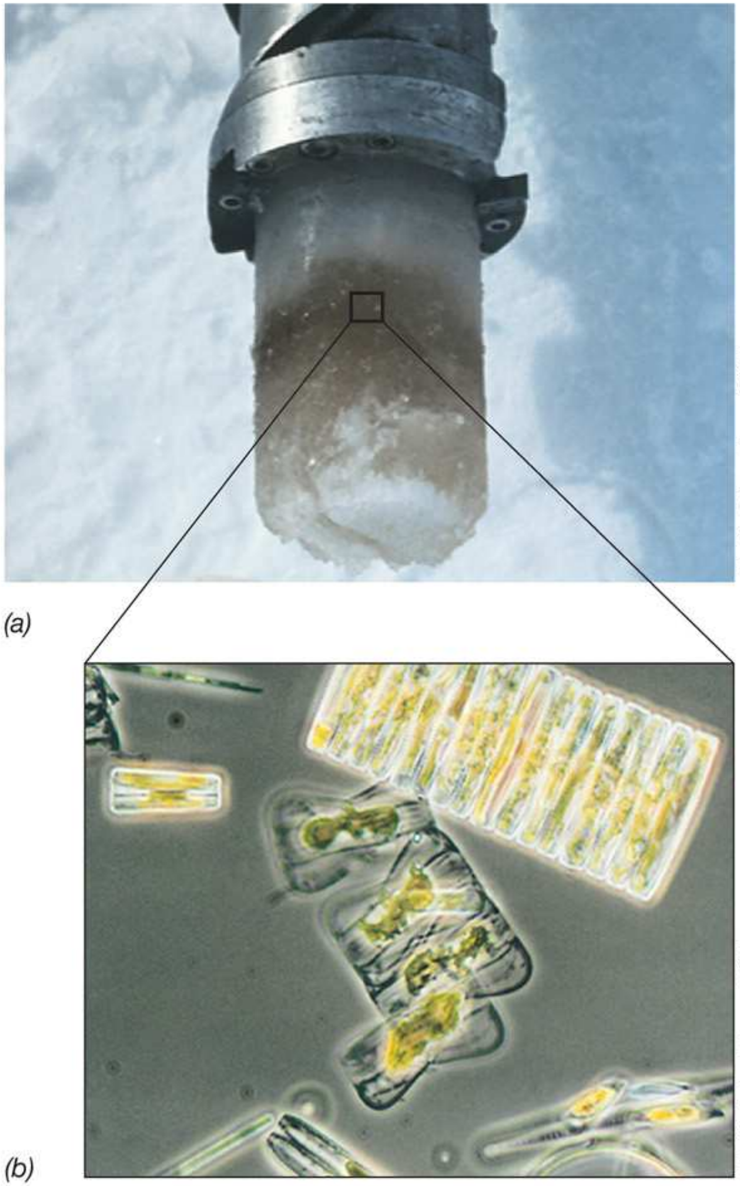
Tab. 6.1 **Limiti superiori di temperatura per la crescita di diversi organismi**

Gruppo	Limiti superiori di temperatura (°C)
Animali	
Pesci e altri vertebrati acquatici	38
Insetti	45-50
Ostracodi (crostacei)	49-50
Piante	
Piante vascolari	45
Muschi	50
Microrganismi eucariotici	
Protozoi	56
Alghe	55-60
Funghi	60-62
Procarioti	
Batteri	
Cianobatteri	70-74
Fototrofi anossigenici	70-73
Chemiorganotrofi/chemiolitotrofi	95
Archea	
Chemiorganotrofi/chemiolitotrofi	113[a]

[a] Limite superiore di temperatura per la crescita dell'organismo *Pyrolobus fumarii*. Specie correlate di *Pyrodictium* possono crescere fino a 121 °C.

Temperature classes of organisms





John Gosink and James T. Staley

(a)

John Gosink and James T. Staley

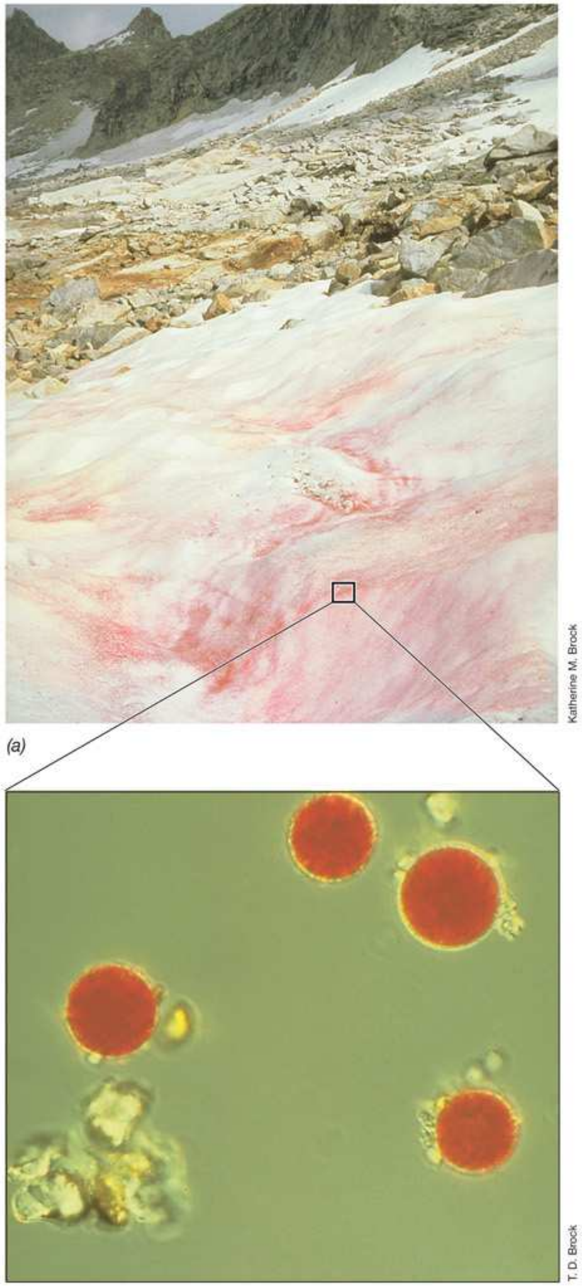
(b)

Deborah Jung and Michael T. Madigan

(c)

Antartic microbial habitats

Snow algae

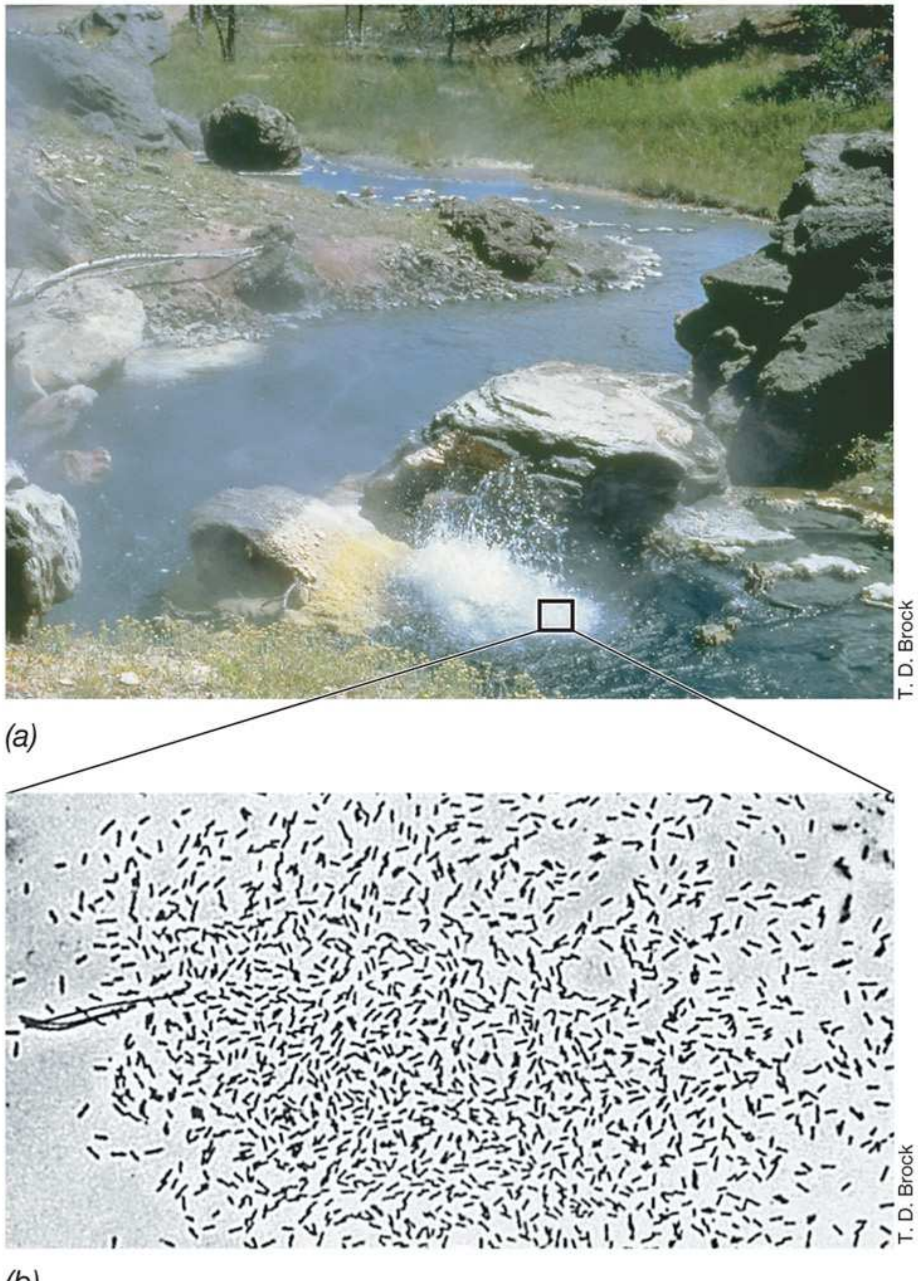


(a)

(b)

Growth of hyperthermophiles in boiling water: microcolony of prokaryotes

that developed on a microscope slide immersed in a boiling spring



Boulder Spring, a small boiling spring in Yellowstone National Park

Growth of thermophilic cyanobacteria in hot spring in Yellowstone National Park

Microbial growth:

the growth at low or high pH

Enzymes that destroy toxic oxygen species

(a) Catalase:

$H_2O_2 + H_2O_2 \rightarrow 2\ H_2O + O_2$

(b) Peroxidase:

$H_2O_2 + NADH + H^+ \rightarrow 2\ H_2O + NAD^+$

(c) Superoxide dismutase:

$O_2^- + O_2^- + 2\ H^+ \rightarrow H_2O_2 + O_2$

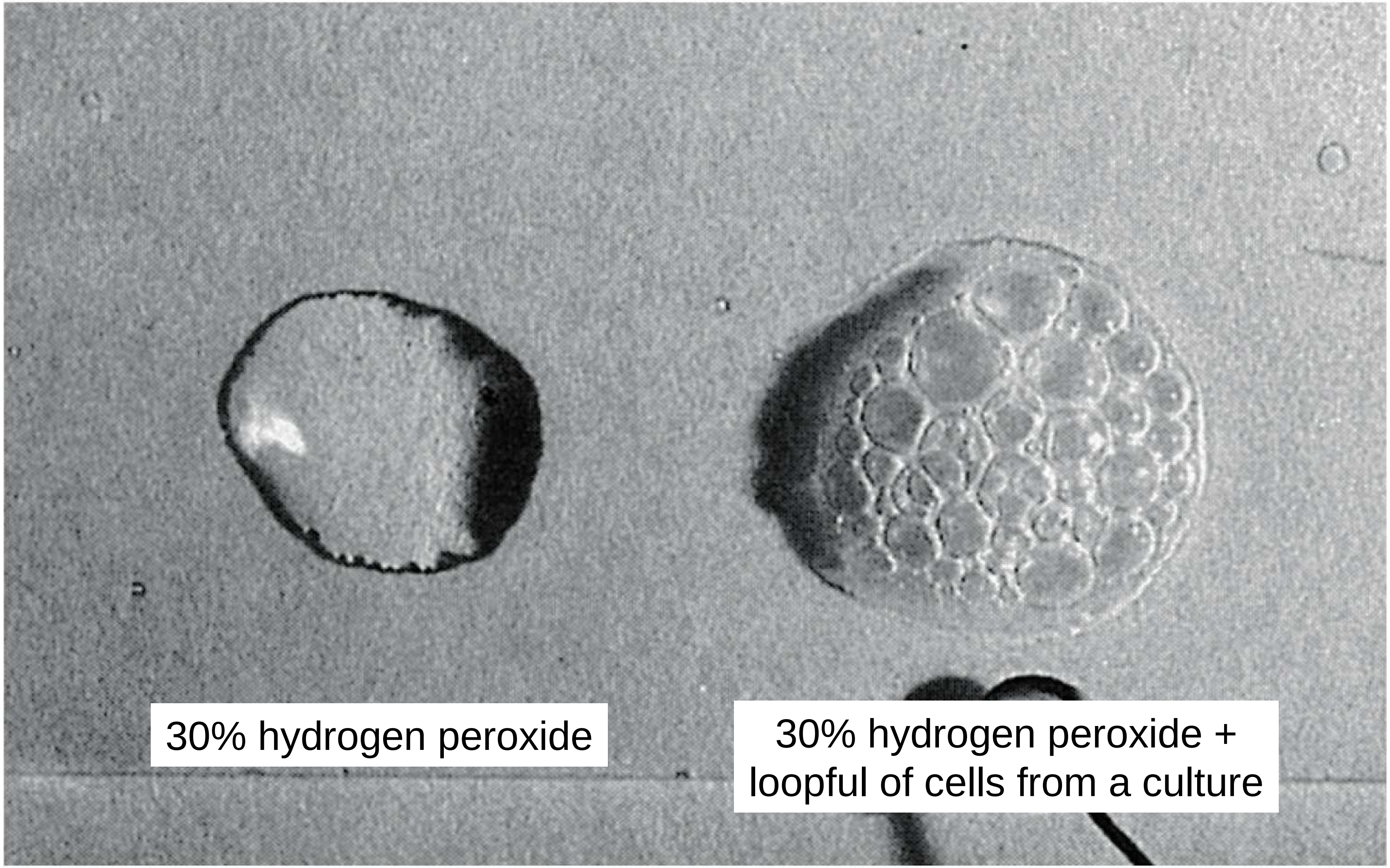
(d) Superoxide dismutase/catalase in combination:

$4\ O_2^- + 4\ H^+ \rightarrow 2\ H_2O + 3\ O_2$

(e) Superoxide reductase:

$O_2^- + 2\ H^+ + \text{cyt}\ c_{\text{reduced}} \rightarrow H_2O_2 + \text{cyt}\ c_{\text{oxidized}}$

Testing a microbial culture for the presence of catalase



T. D. Brock

Tab. 2.1 Classi ed esempi di estremofili[a]

Estremi	Tipo	Genere /Specie	Dominio	Habitat	Minimo	Optimum	Massimo
Temperatura							
Alta	Ipertermofili	*Pyrolobus fumarii*	Archea	Molto caldo, sorgenti idrotermali sottomarine	90 °C	106 °C	113 °C[b]
Bassa	Psicrofili	*Polaromonas vacuolata*	Batteri	Banchise polari	0 °C	**4 °C**	12 °C
pH							
Basso	Acidofili	*Picrophilus oshimae*	Archea	Sorgenti calde acide	–0,06 °C	**0,7 °C**[c]	4
Alto	Alcalofili	*Natronobacterium gregoryi*	Archea	Laghi con elevata concentrazione di carbonato di sodio	8,5 °C	10 °C[d]	12
Pressione	Barofili	*Moritella yayanosii*[e]	Batteri	Fondali oceanici	500 atm	**700 atm**	> 1000 atm
Concentrazione di sali (NaCl)	Alofili	*Halobacterium salinarum*	Archea	Salino	15%	**25%**	32% (saturazione)

[a] Di ciascuna categoria è citato l'organismo che detiene il primato in relazione alla richiesta di condizioni di crescita estreme.
[b] Un nuovo archea isolato sembra poter crescere fino a 121 °C.
[c] *P. oshimae* è anche un termofilo con crescita ottimale a 60 °C.
[d] *N. gregoryi* è anche un alofilo estremo con crescita ottimale al 20% di NaCl.
[e] *Moritella yayanosii* è anche uno psicrofilo con temperature di crescita ottimali di circa 4 °C.