Physical requirements

- Temperature
- Oxygen
- pH
- Osmotic conditions

Temperature

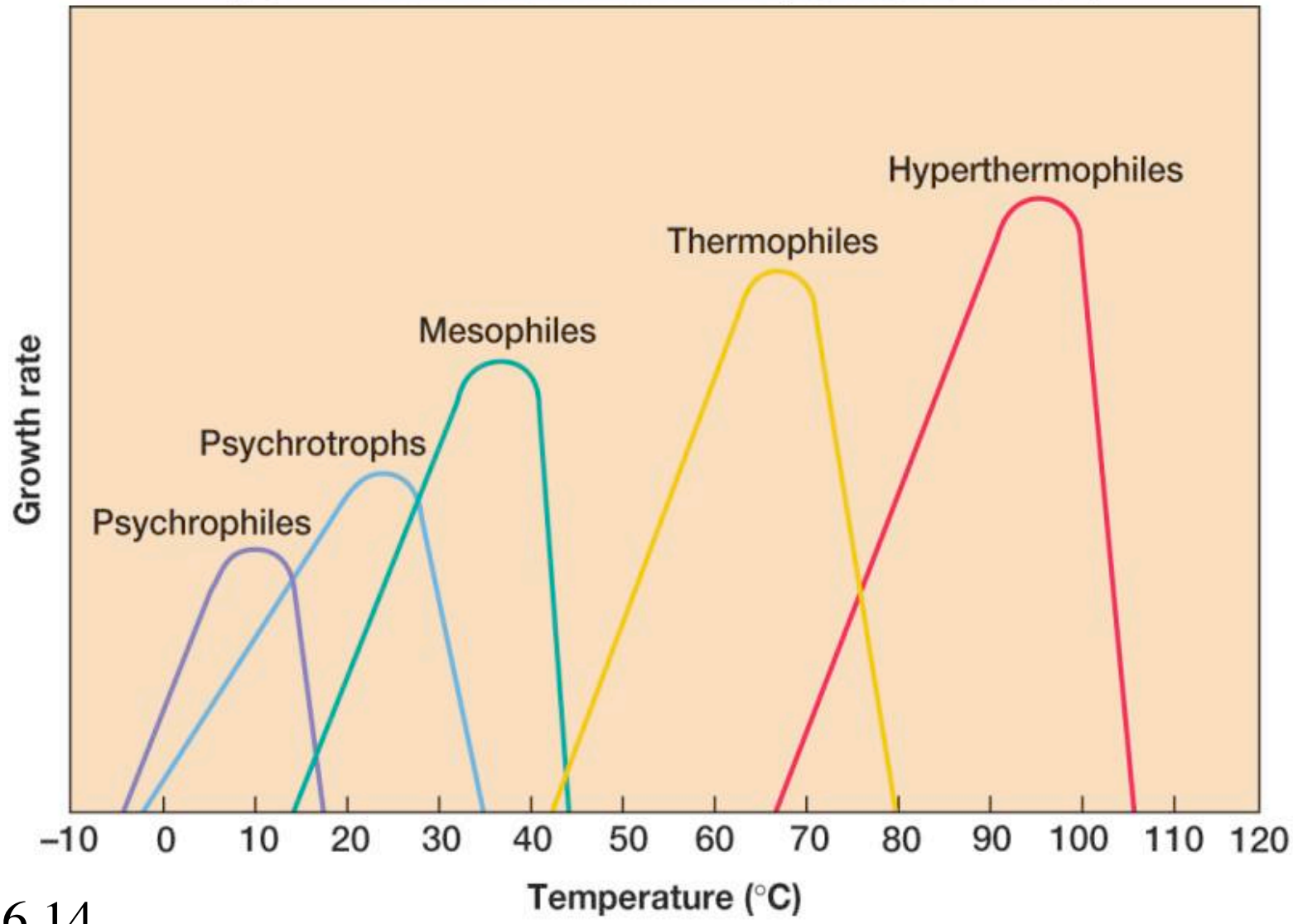
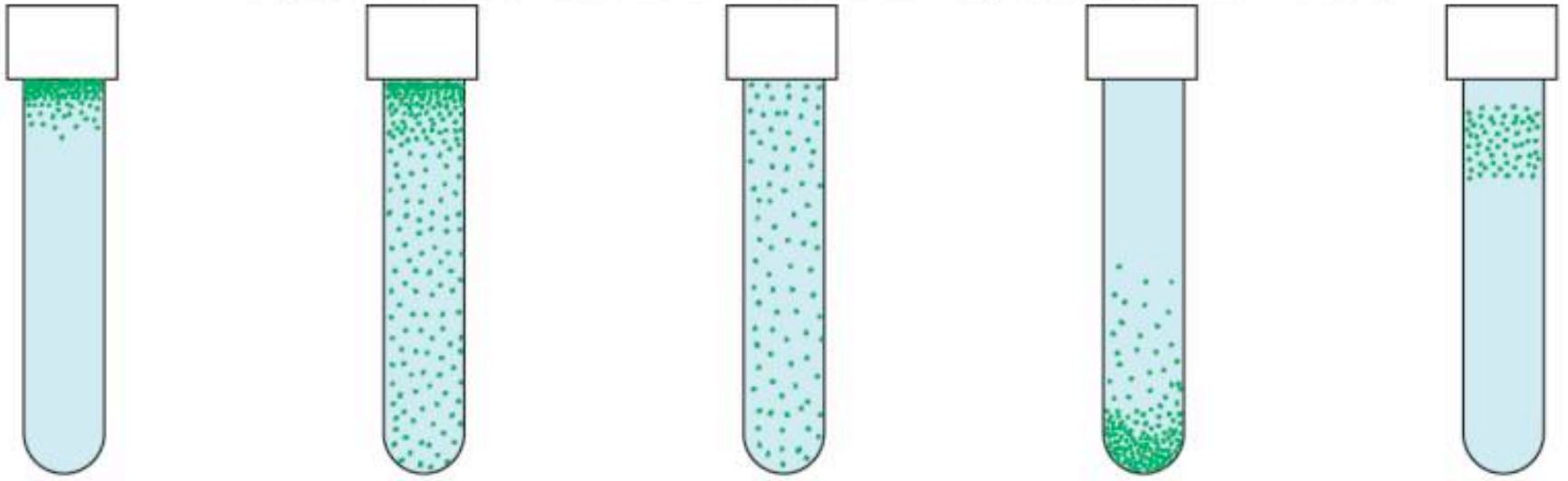


Fig. 6.14

Oxygen



Obligate aerobe	Facultative anaerobe	Aerotolerant anaerobe	Strict anaerobe	Microaerophile
Enzyme content				
+ SOD + Catalase	+ SOD + Catalase	+ SOD – Catalase	– SOD – Catalase	+ SOD +/– Catalase (low levels)

Fig. 6.15

Toxic Forms of Oxygen

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

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

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

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

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

Toxic O_2-neutralizing enzymes

Superoxide Dismutase:

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

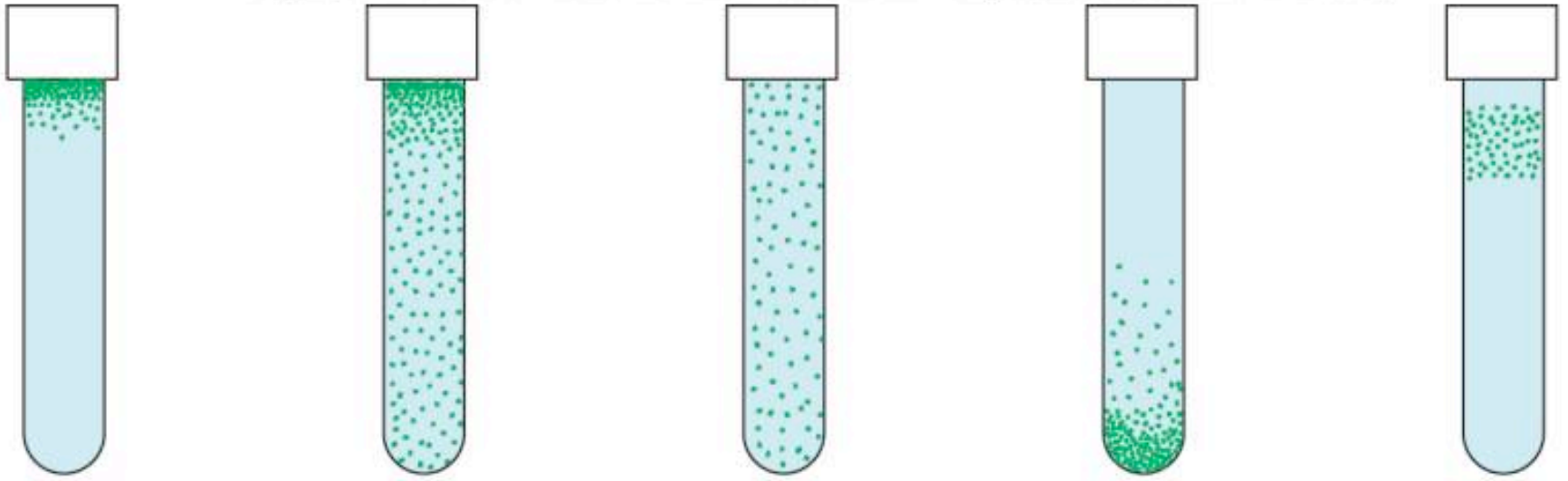
Catalase:

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

Peroxidase:

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

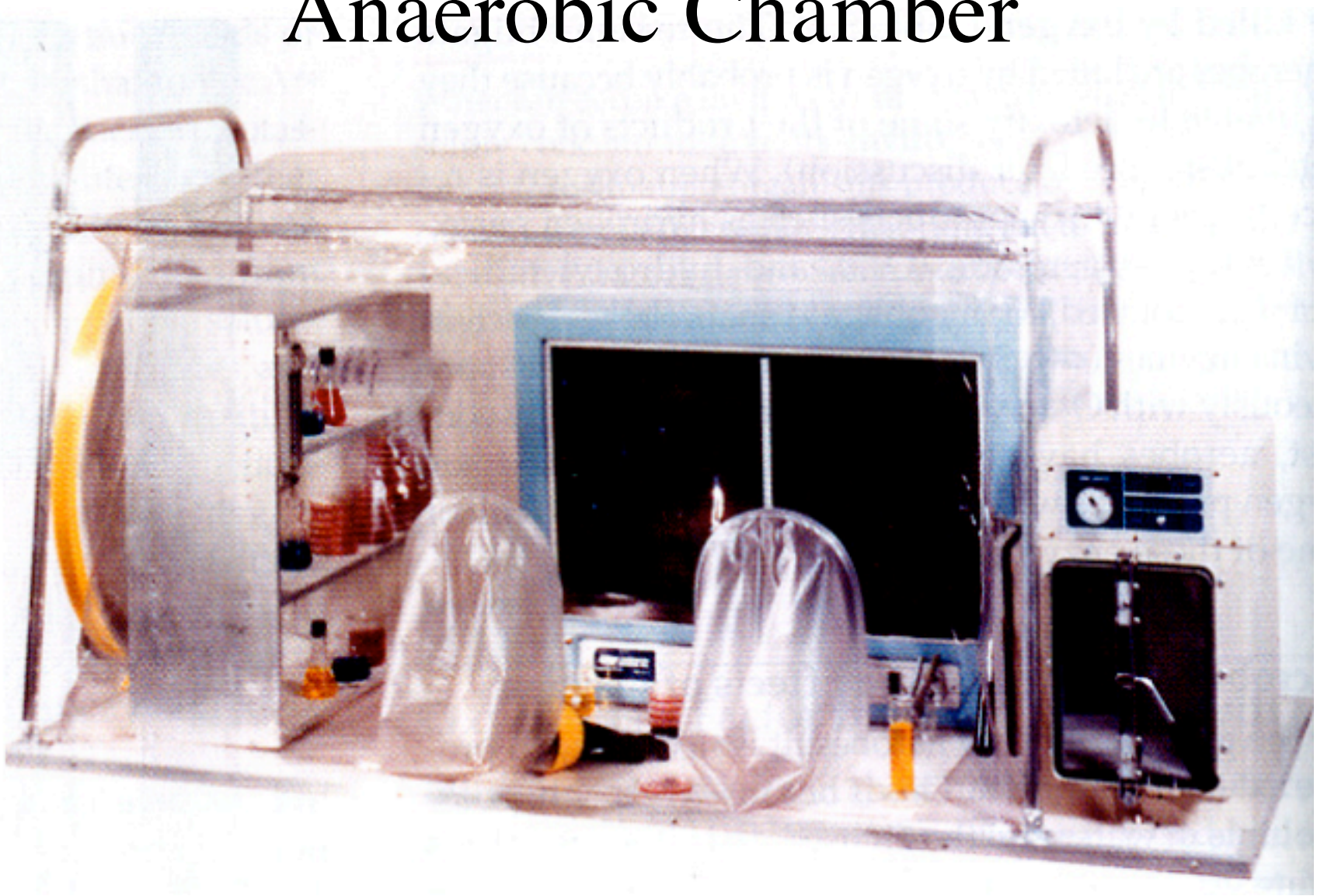
Oxygen



Obligate aerobe	Facultative anaerobe	Aerotolerant anaerobe	Strict anaerobe	Microaerophile
Enzyme content				
+ SOD + Catalase	+ SOD + Catalase	+ SOD – Catalase	– SOD – Catalase	+ SOD +/– Catalase (low levels)

Fig. 6.15

Anaerobic Chamber



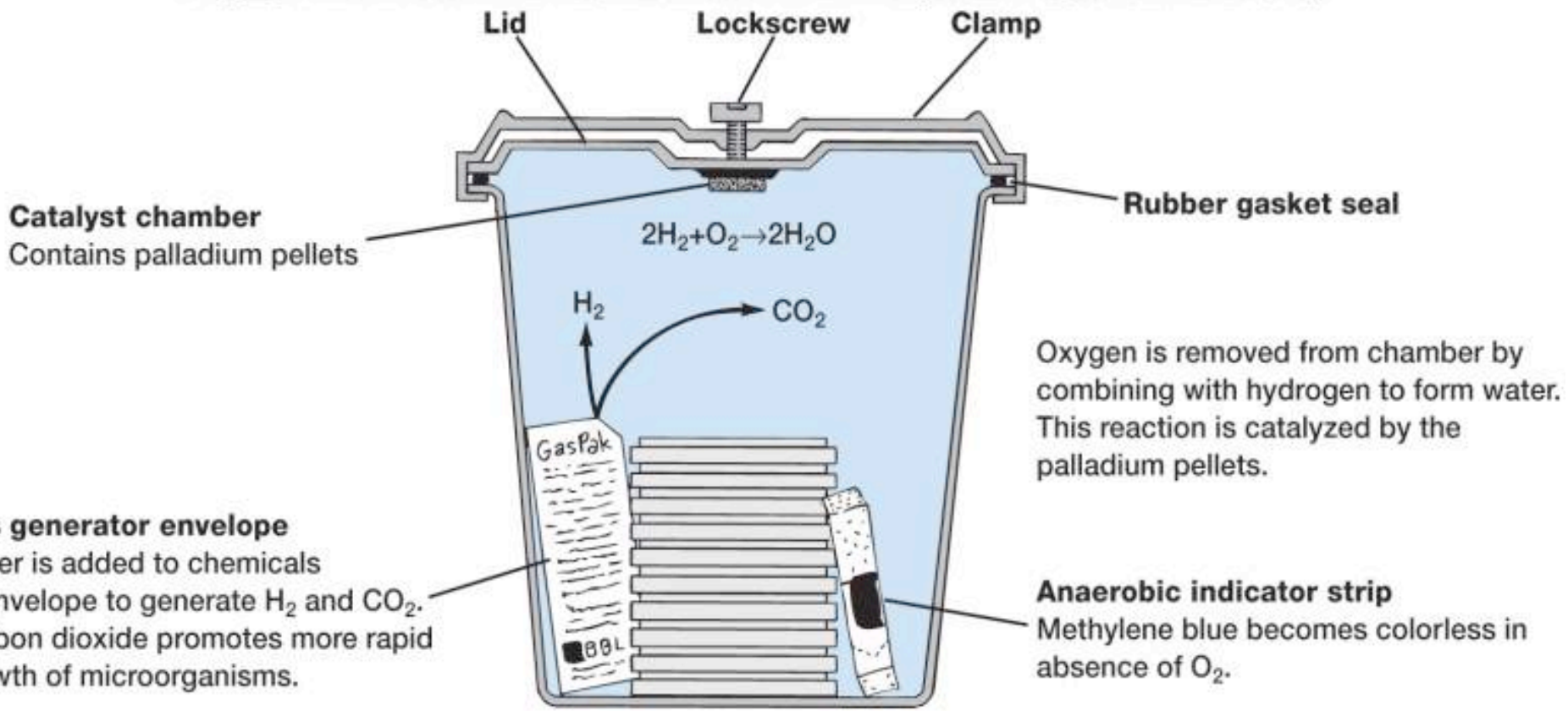


Fig. 6.17

pH

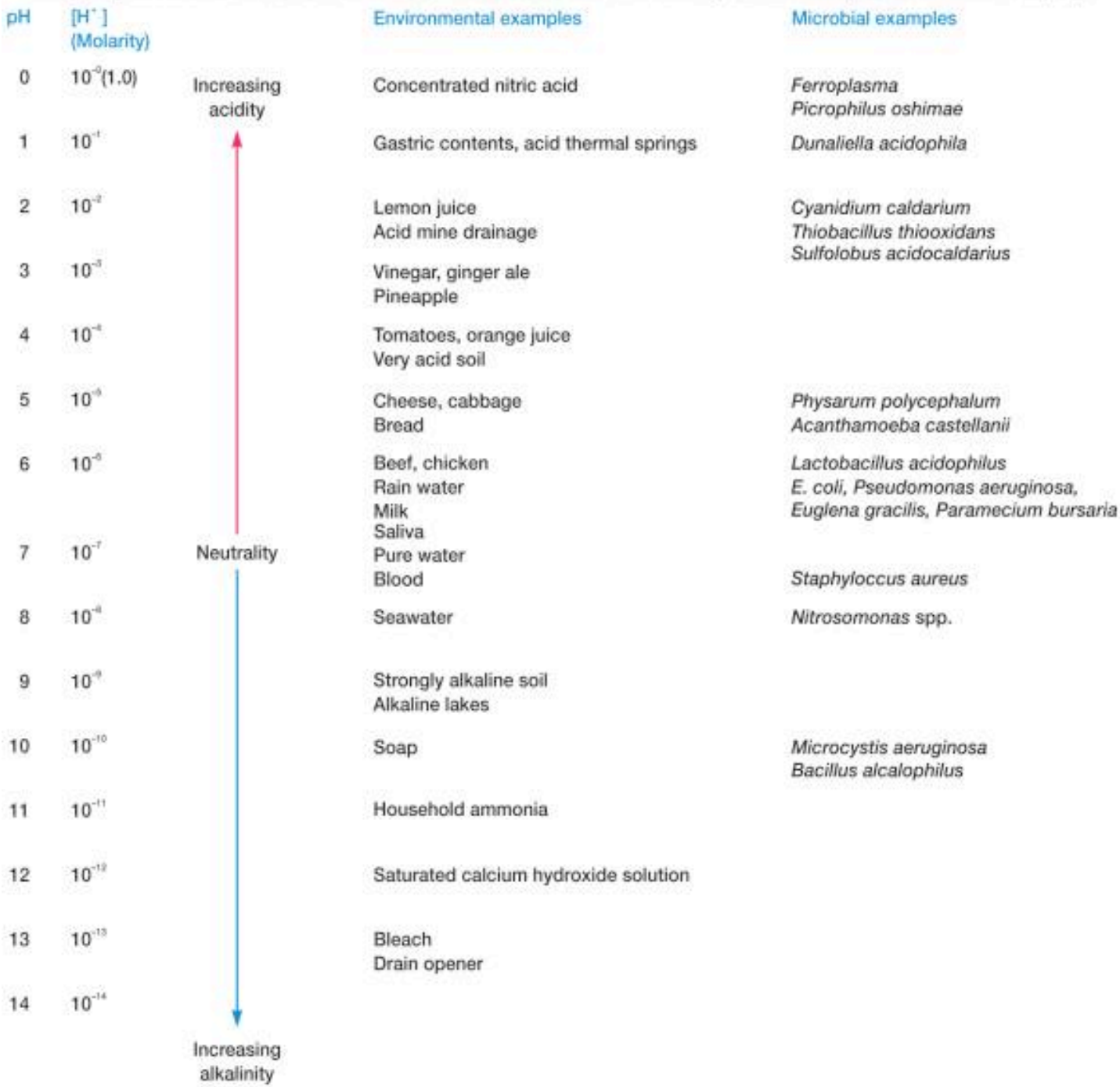


Fig. 6.12

Osmotic pressure

- isotonic=
  - concentrations of solutes same on both sides membrane
- hypotonic
  - more water outside of cell
  - concentration of solutes greater inside cell
  - low osmotic pressure
- hypertonic-
  - more water inside cell
  - concentration of solutes greater outside cell
  - high osmotic pressure

Osmotolerance

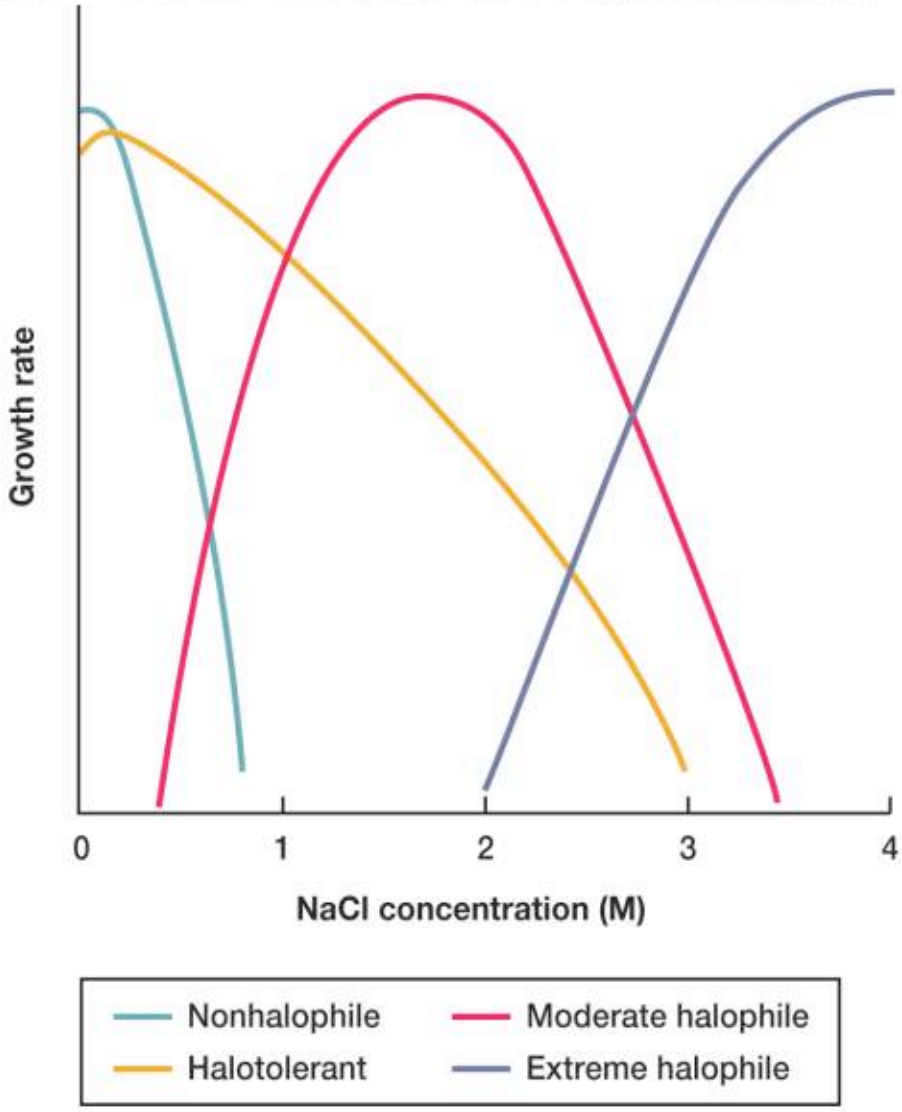


Fig. 6.11

Osmolarity
(Solute concentration)

Table 6.4

Approximate Lower a_w Limits for Microbial Growth

Water Activity	Environment	Bacteria	Fungi	Algae
1.00—Pure water	Blood	Most gram-negative		
	Plant wilt	nonhalophiles		
	Seawater			
0.95	Bread	Most gram-positive rods	*Basidiomycetes*	Most algae
0.90	Ham	Most cocci, *Bacillus*	*Fusarium*	
			Mucor, Rhizopus	
			Ascomycetous yeasts	
0.85	Salami	*Staphylococcus*	*Saccharomyces rouxii* (in salt)	
0.80	Preserves		*Penicillium*	
0.75	Salt lakes	*Halobacterium*	*Aspergillus*	*Dunaliella*
	Salted fish	*Actinospora*		
0.70			*Aspergillus*	
	Cereals, candy, dried fruit			
0.60			*Saccharomyces rouxii* (in sugars)	
	Chocolate			
	Honey		*Xeromyces bisporus*	
	Dried milk			
0.55—DNA disordered				

Adapted from A. D. Brown, "Microbial Water Stress," in *Bacteriological Reviews*, 40(4):803–846 1976. Copyright © 1976 by the American Society for Microbiology. Reprinted by permission.

Chemical requirements

Carbon

Nitrogen

Sulfur

Phosphorous

Potassium

Magnesium

Calcium

Trace elements:
iron, copper, zinc

Table 5.4
Examples of Defined Media

BG–11 Medium for Cyanobacteria	Amount (g/liter)
$NaNO_3$	1.5
$K_2HPO_4 \cdot 3H_2O$	0.04
$MgSO_4 \cdot 7H_2O$	0.075
$CaCl_2 \cdot 2H_2O$	0.036
Citric acid	0.006
Ferric ammonium citrate	0.006
EDTA (Na_2Mg salt)	0.001
Na_2CO_3	0.02
Trace metal solution[a]	1.0 ml/liter
Final pH 7.4	

Medium for *Escherichia coli*	Amount (g/liter)
Glucose	1.0
Na_2HPO_4	16.4
KH_2PO_4	1.5
$(NH_4)_2SO_4$	2.0
$MgSO_4 \cdot 7H_2O$	200.0 mg
$CaCl_2$	10.0 mg
$FeSO_4 \cdot 7H_2O$	0.5 mg
Final pH 6.8–7.0	

Sources: Data from Rippka, et al. *Journal of General Microbiology,* 111:1–61, 1979; and S. S. Cohen, and R. Arbogast, *Journal of Experimental Medicine,* 91:619, 1950.

[a]The trace metal solution contains H_3BO_3, $MnCl_2 \cdot 4H_2O$, $ZnSO_4 \cdot 7H_2O$, $Na_2Mo_4 \cdot 2H_2O$, $CuSO_4 \cdot 5H_2O$, and $Co(NO_3)_2 \cdot 6H_2O$.

Table 5.5
Some Common Complex Media

Nutrient Broth	Amount (g/liter)
Peptone (gelatin hydrolysate)	5
Beef extract	3
Tryptic Soy Broth	
Tryptone (pancreatic digest of casein)	17
Peptone (soybean digest)	3
Glucose	2.5
Sodium chloride	5
Dipotassium phosphate	2.5
MacConkey Agar	
Pancreatic digest of gelatin	17.0
Pancreatic digest of casein	1.5
Peptic digest of animal tissue	1.5
Lactose	10.0
Bile salts	1.5
Sodium chloride	5.0
Neutral red	0.03
Crystal violet	0.001
Agar	13.5

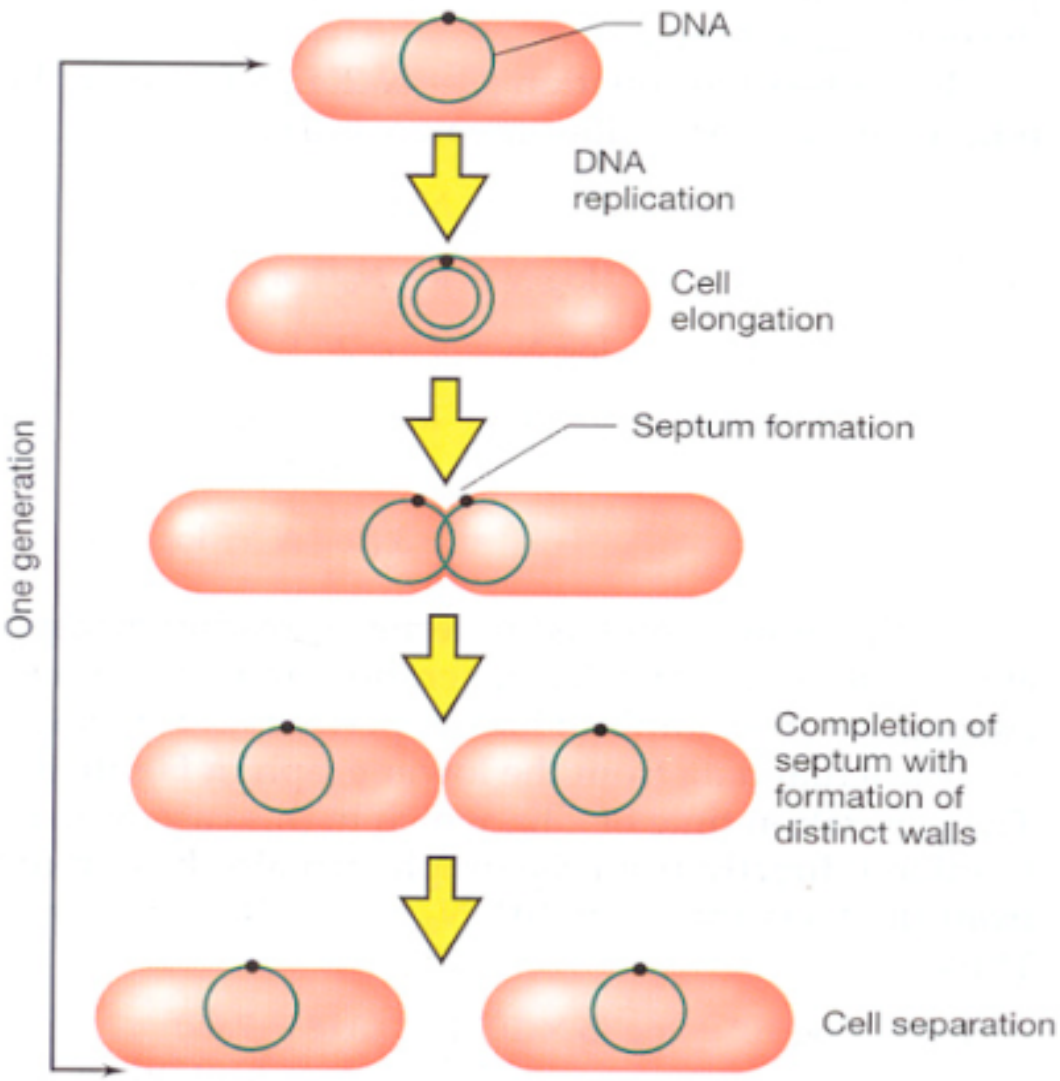
Other types of media-
check them out in lab!

- Selective
  - suppresses growth of unwanted bacteria
  - encourages growth of desired bacteria

- Differential
  - distinguish colonies of desired organism from other colonies

- Enrichment
  - increase number of organisms
    - (few-> many)

Binary fission



Microbial Growth Curve

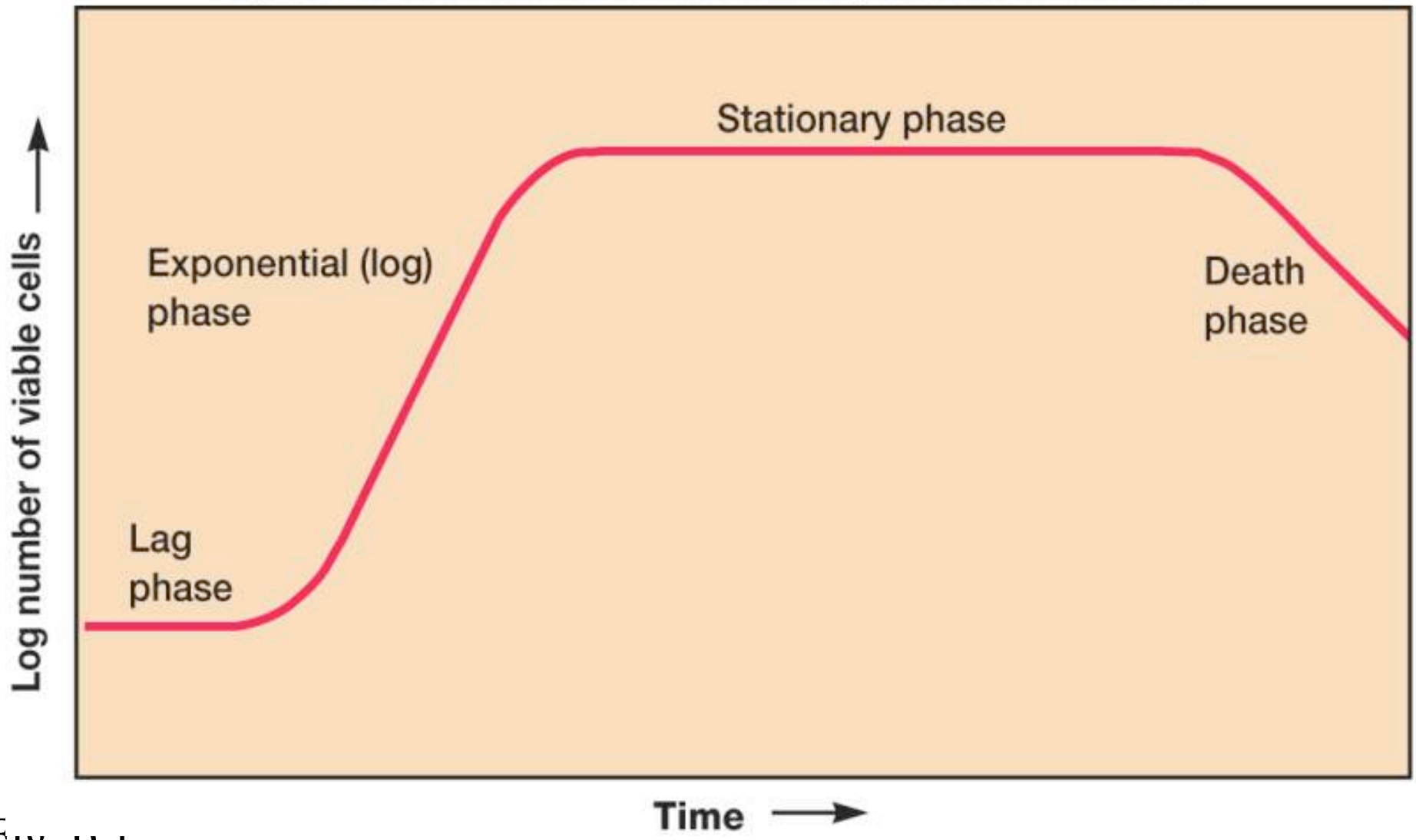


Fig. 6.1

Exponential Growth

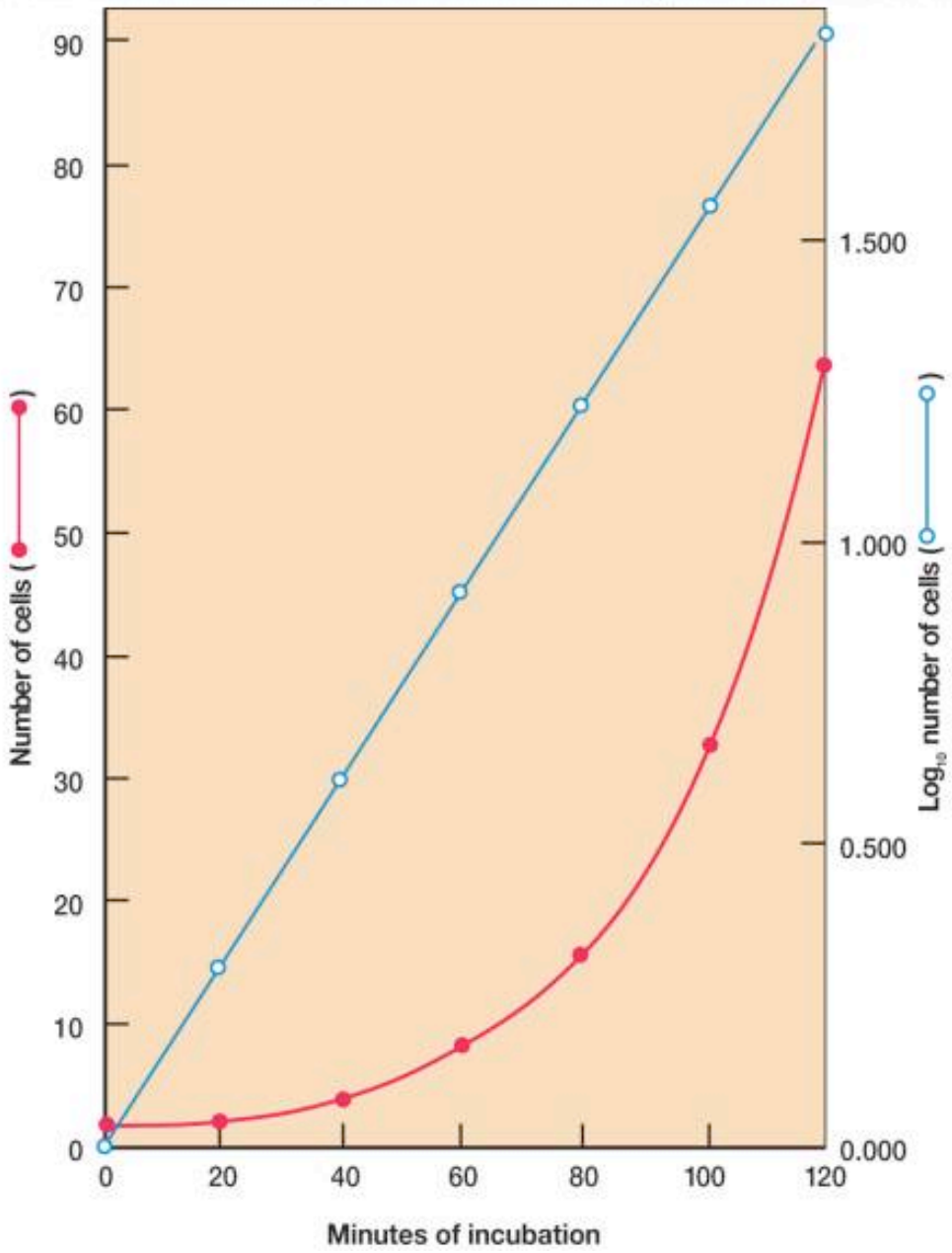


Fig. 6.3

Table 6.1
An Example of Exponential Growth

Time[a]	Division Number	2^n	Population ($N_o \times 2^n$)	$\log_{10} N_t$
0	0	$2^0 = 1$	1	0.000
20	1	$2^1 = 2$	2	0.301
40	2	$2^2 = 4$	4	0.602
60	3	$2^3 = 8$	8	0.903
80	4	$2^4 = 16$	16	1.204
100	5	$2^5 = 32$	32	1.505
120	6	$2^6 = 64$	64	1.806

[a]The hypothetical culture begins with one cell having a 20-minute generation time.

Generation time determination

$N_t = N_o \times 2^n$

$n = \log N_t - \log N_o / \log 2$

$k = n/t$

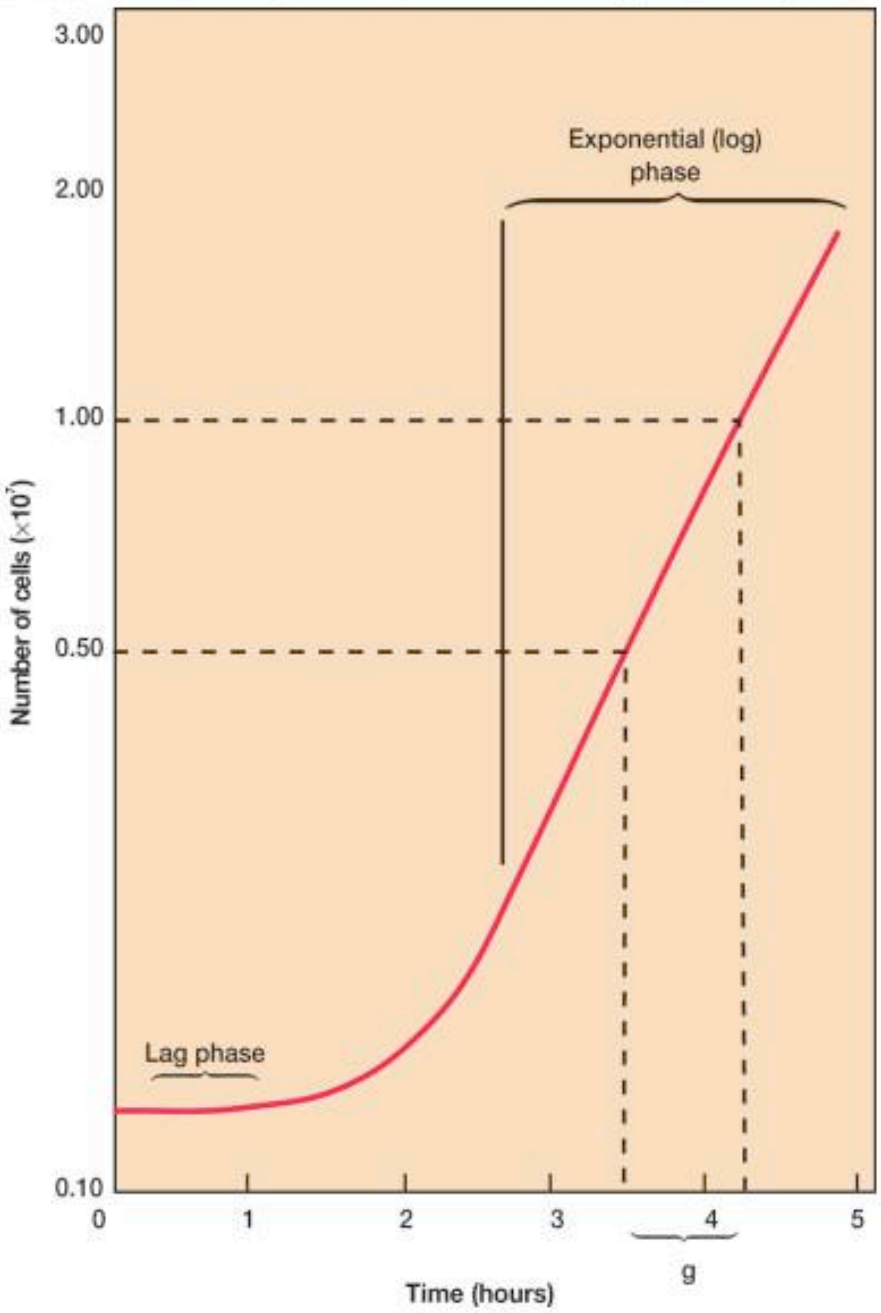


Fig. 6.4

Table 6.2
Generation Times for Selected Microorganisms

Microorganism	Temperature (°C)	Generation Time (Hours)
Bacteria		
Beneckea natriegens	37	0.16
Escherichia coli	40	0.35
Bacillus subtilis	40	0.43
Staphylococcus aureus	37	0.47
Pseudomonas aeruginosa	37	0.58
Clostridium botulinum	37	0.58
Rhodospirillum rubrum	25	4.6–5.3
Anabaena cylindrica	25	10.6
Mycobacterium tuberculosis	37	≈12
Treponema pallidum	37	33
Algae		
Scenedesmus quadricauda	25	5.9
Chlorella pyrenoidosa	25	7.75
Asterionella formosa	20	9.6
Euglena gracilis	25	10.9
Ceratium tripos	20	82.8
Protozoa		
Tetrahymena geleii	24	2.2–4.2
Leishmania donovani	26	10–12
Paramecium caudatum	26	10.4
Acanthamoeba castellanii	30	11–12
Giardia lamblia	37	18
Fungi		
Saccharomyces cerevisiae	30	2
Monilinia fructicola	25	30

Chemostat

Continuous Culture

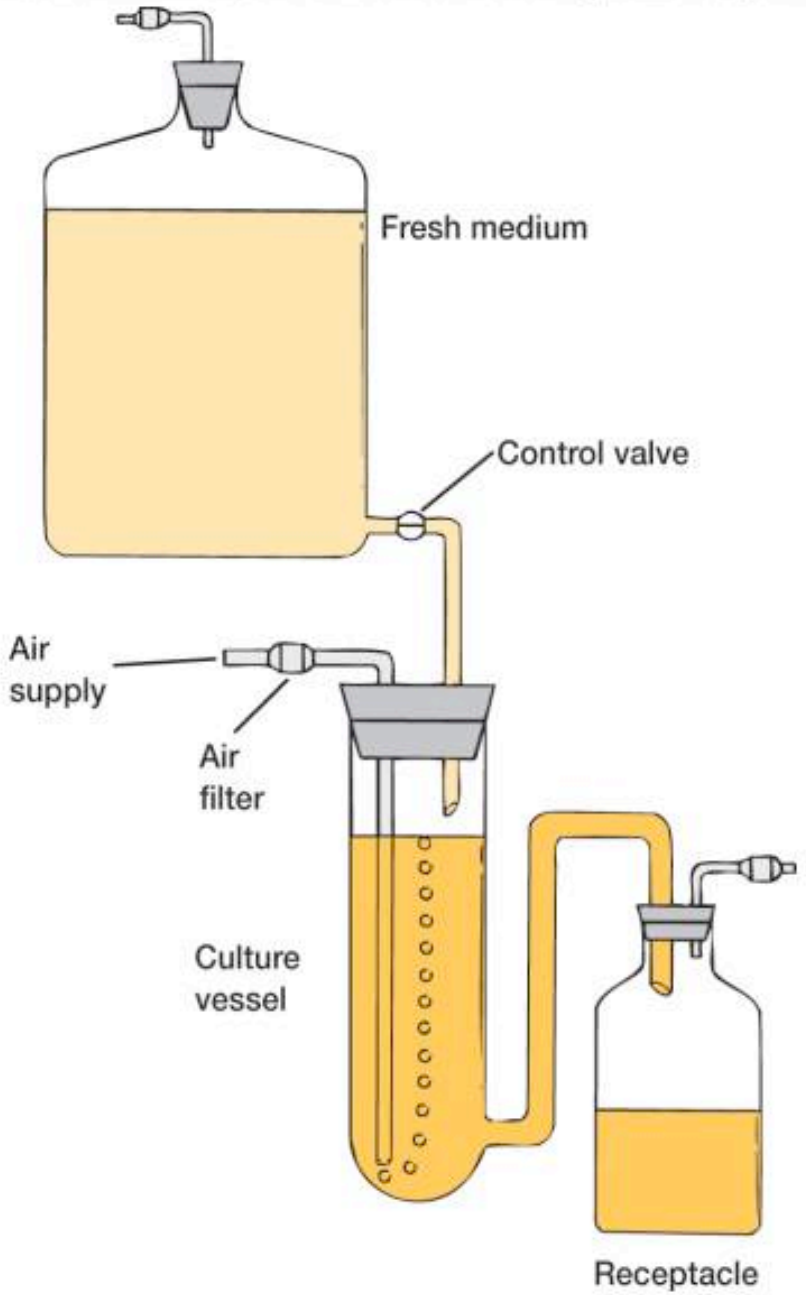


Fig. 6.9

Turbidity(Absorbance)

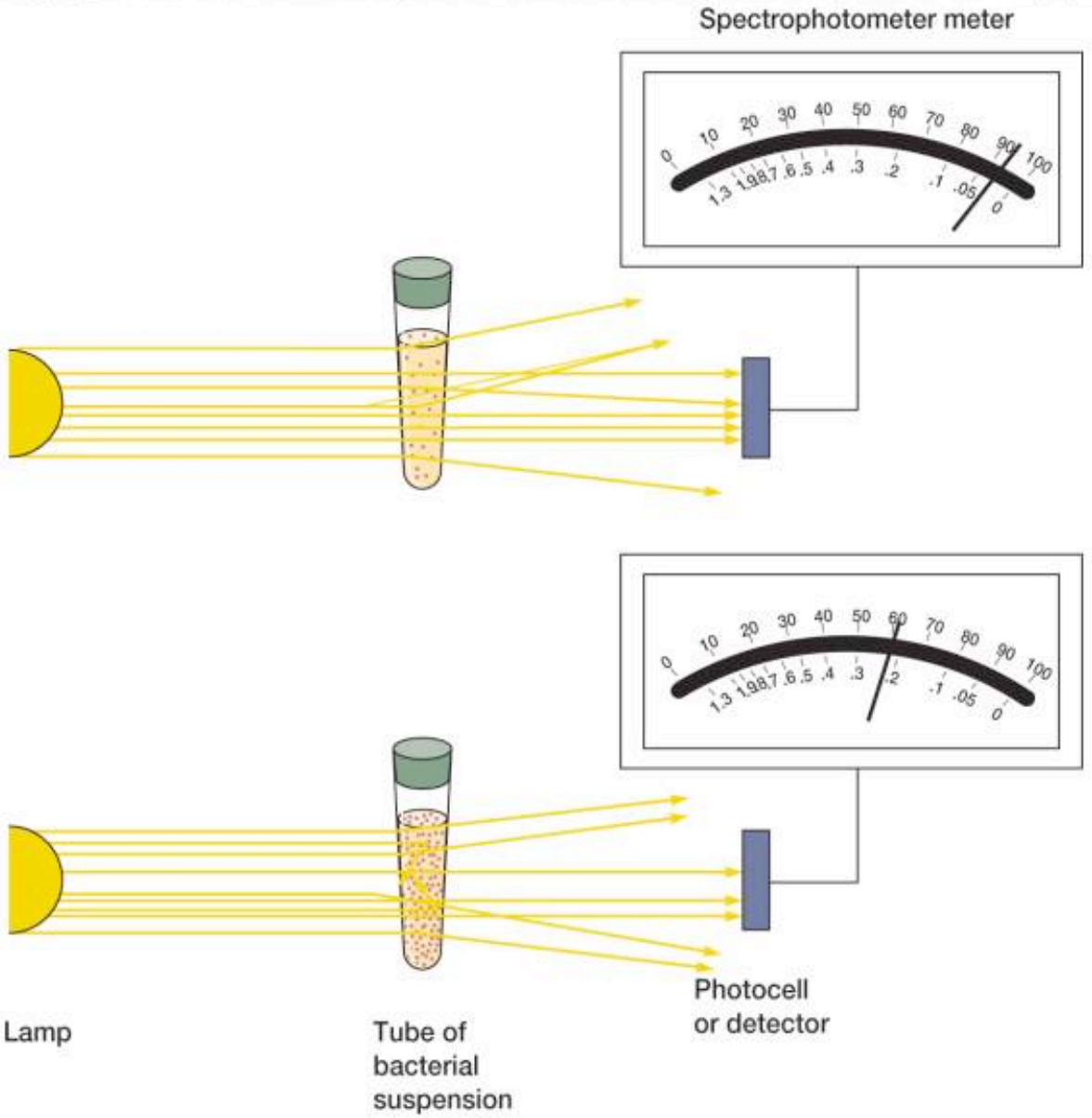
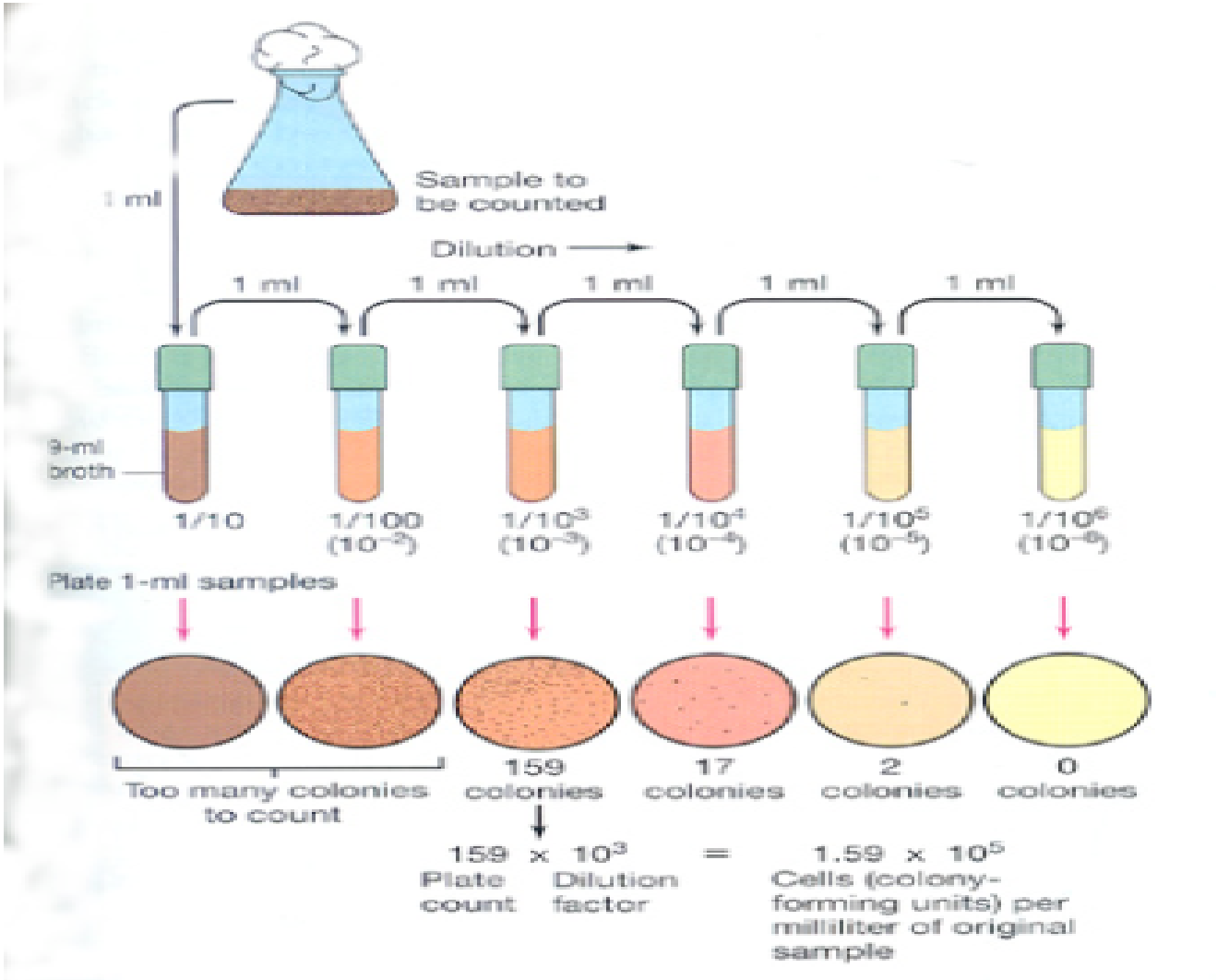


Fig. 6.8

Viable cell count



Direct cell count

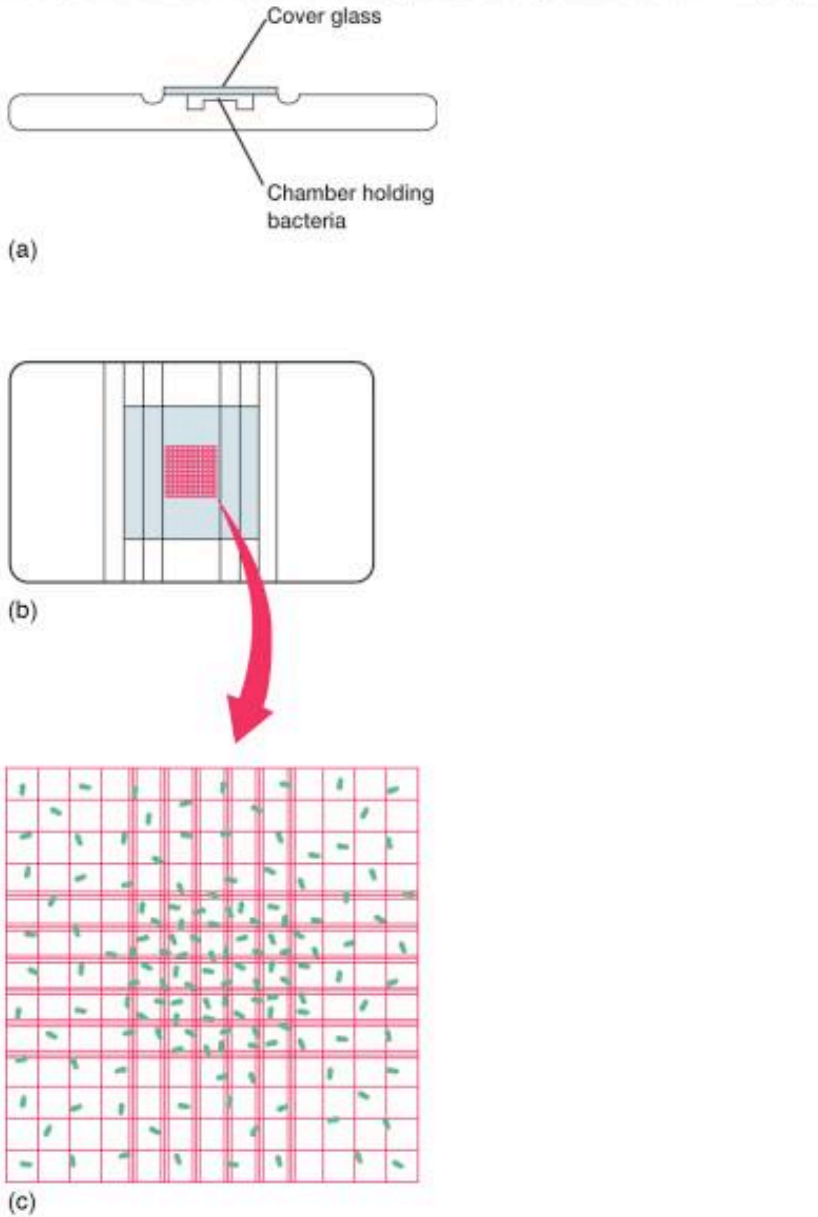
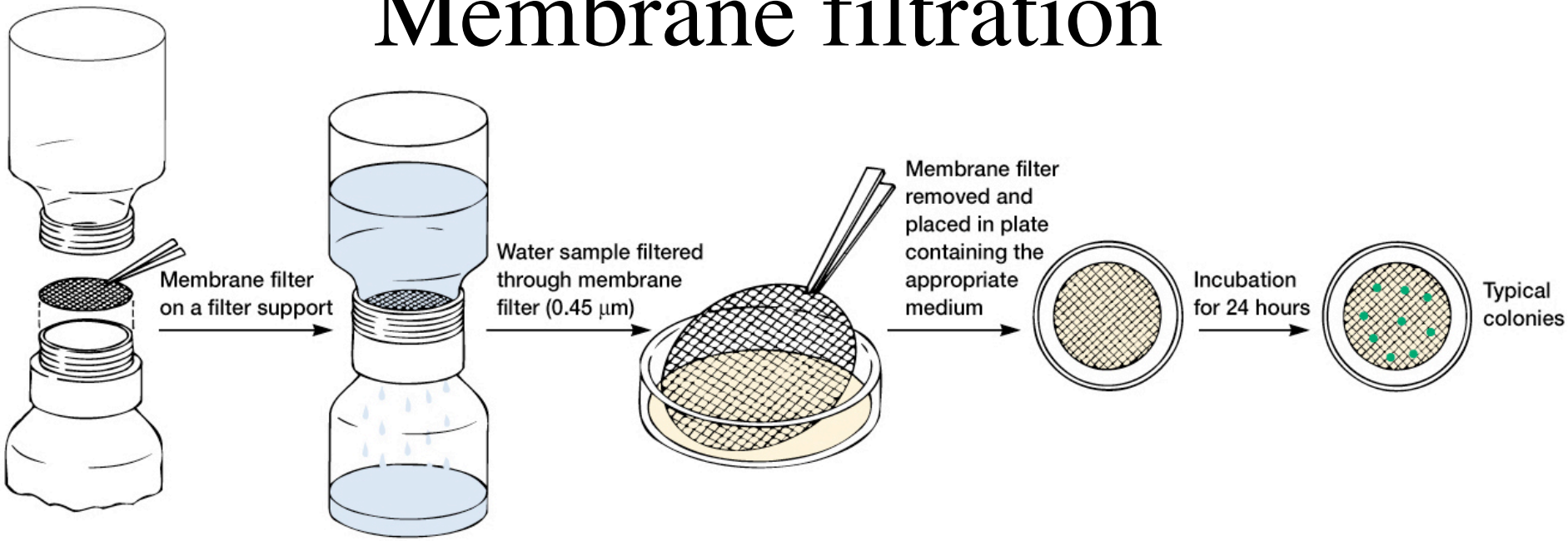


Fig. 6.5

Membrane filtration



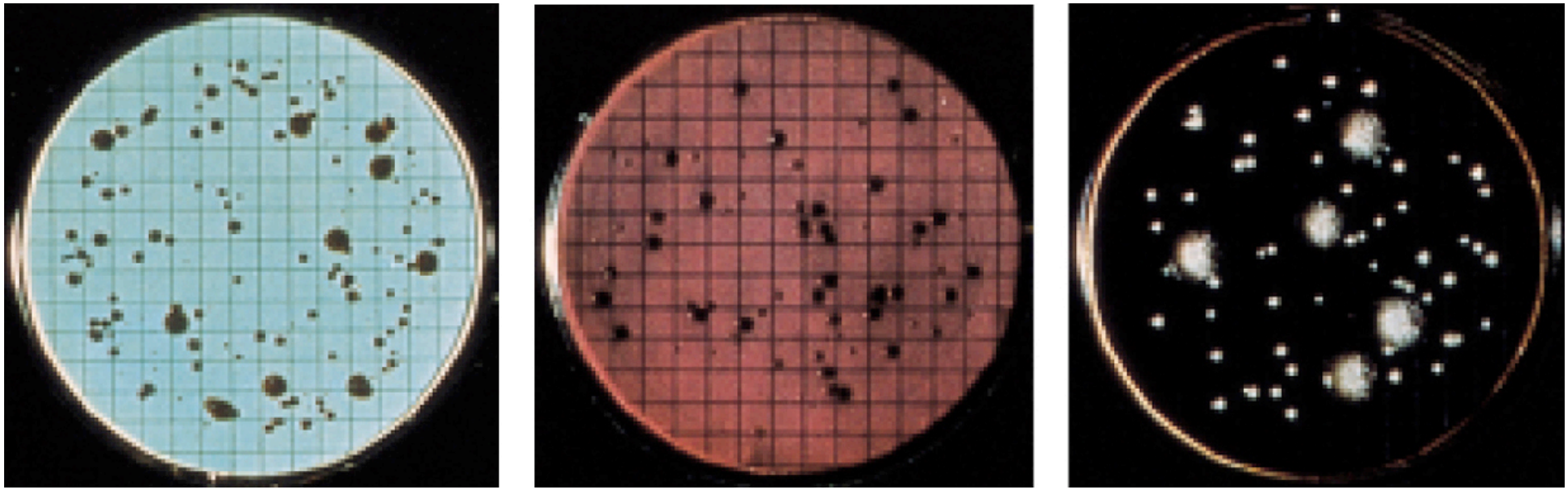


Fig. 6.6