WATER

Reference: Nelson & Cox
Lehninger: Principles of
Biochemistry 5th ed (2008) Chap. 2

OBJECTIVES -Water

1. Recognize and interpret physical and chemical properties of water including:

a. Colligative properties

b. Dielectric constant

c. Viscosity and surface tension

d. Types of bonds

i. Covalent

ii. Hydrogen bond

iii. Electrostatic

iv. Van der Waals forces

e. Hydration properties and requirements

2. Distinguish between states of water

a. Solid

b. Liquid

c. Gas

pH and Buffers

1. **Define and interpret pH**
   a. Calculate pH given hyrogen ion conc
   b. Calculate hydrogen ion conc given pH
   c. Draw a titration curve of a strong acid
      with a strong base
   d. Draw a titration curve of a weak acid
      with a strong base
2. **Recognize normal and abnormal pH values**
   a. under various physiological activities
   b. during states of health and disease
      i. Tooth decay

pH and Buffers (contin)

3. Define and be able to interpret a titration curve in terms of pK’s and maximum and minimum buffering power.
4. Distinguish between a weak and a strong acid and be able to calculate pH values of buffering systems using the Henderson –Hasselbach equation.
5. Explain and be able to calculate buffering capacity.

% Body weight loss

0
1 Thirst
2 Increased thirst, loss of appetite, discomfort
3 Impatience, decreased blood volume
4 Nausea, slowing of physical work
5 Difficulty concentrating, apathy, tingling extremities
6 Increasing body temperature, pulse and respiration rate
7 Stumbling, headache
8 Dizziness, labored breathing
9 Weakness, mental confusion
10 Muscle spasms, indistinct speech
11 Kidney failure, poor circulation due to decreased blood volume

Figure 11.13 **Effects of progressive dehydration.**

6 SUNDAY, FEBRUARY 13, 2012 news@prdailysun.net LATIN AMERICA

PUERTO RICO DAILY SUN

Mystery disease kills thousands in Central America

FILADELFO ALEMAN
The Associated Press

CHICHIGALPA, NICARAGUA

Jesus Ignacio Flores started working when he was 16, laboring long hours on construction sites and in the fields of his country's biggest sugar plantation.

Three years ago his kidneys started to fail and flooded his body with toxins. He became too weak to work, wracked by cramps, headaches and vomiting.

On Jan. 19 he died on the porch of his house. He was 51. His withered body was dressed by his weeping wife, embraced a final time, then carried in the bed of a pickup truck to a grave on the edge of Chichigalpa, a town in Nicaragua's sugar-growing heartland, where studies have found more than one in four men showing symptoms of chronic kidney disease.

A mysterious epidemic is devastating the Pacific coast of Central America, killing more than 24,000 people in El Salvador and Nicaragua since 2000 and striking thousands of others with chronic kidney disease at rates unseen virtually anywhere else. Scientists say they have received reports of the phenomenon as far north as southern Mexico and as far south as Panama.

Last year it reached the point where El Salvador's health minis-

AP /Esteban Felix

In this Tuesday, Jan. 24, 2012 photo, Segundo Zapata Palacios rests in a hospital as his wife Emma Vanegas sits at his bedside in Chinandega, Nicaragua. Zapata, who worked as a sugar cane cutter for 20 years at the San Antonio sugar plantation, died two days later of chronic kidney disease on Jan. 26 at the age of 49. A mysterious epidemic is devastating the Pacific coast of Central America, killing more than 24,000 people in El Salvador and Nicaragua since 2000 and striking thousands of others with chronic kidney disease at rates unseen virtually anywhere else. Many of the victims were manual laborers or worked in the sugarcane fields that cover much of the coastal lowlands.

have used for years with virtually none of the protections required in more developed countries. But a growing body of evidence supports a more complicated and counterintuitive hypothesis

Public Health, who has worked on a series of studies of the kidney disease epidemic.

Because hard work and intense heat alone are hardly a phenomenon unique to Central America, some researchers will not rule

Heavy metals, chemicals, toxins have all been considered, but to date there have been no leading candidates to explain what's going on in Nicaragua ...

"As these possibilities get exhausted recurrent dehydration is

known to medicine.

In nations with more d
oped health systems, the di
that impairs the kidney's a
to cleanse the blood is
nosed relatively early
treated with dialysis in m
clinics. In Central Am
many of the victims treat
selves at home with a ch
but less efficient form of
sis, or go without any dial
all.

At a hospital in
Nicaraguan town of Ch
dega, Segundo Zapata Pa
sat motionless in his room
over with his head on the

"He no longer wants to
said his wife, Enma Vaneg

His levels of creatini
chemical marker of kidne
ure, were 25 times the n
amount.

His family told him h
being hospitalized to r
dialysis. In reality, the hop
to ease his pain before h
evitable death, said Ca
Rios, a leader of Nicaragu
sociation of Chronic K
Disease Patients, a suppo
advocacy group.

"There's already nothi
do," she said. "He was hos
ized on Jan. 23 just waiti
die."

Zapata Palacios passed
on Jan. 26. He was 49.

Working with scientists
Costa Rica, El Salvador
Nicaragua, Wesseling

Workers in cane fields, construction and other labor intensive jobs suffer repeated episodes of severe dehydration resulting in kidney failure such as the patient in the picture above.

Water Requirement per Day

Women = 91 oz Ie 11 8 oz glasses
Men = 125 oz Ie. 15 8 oz glasses

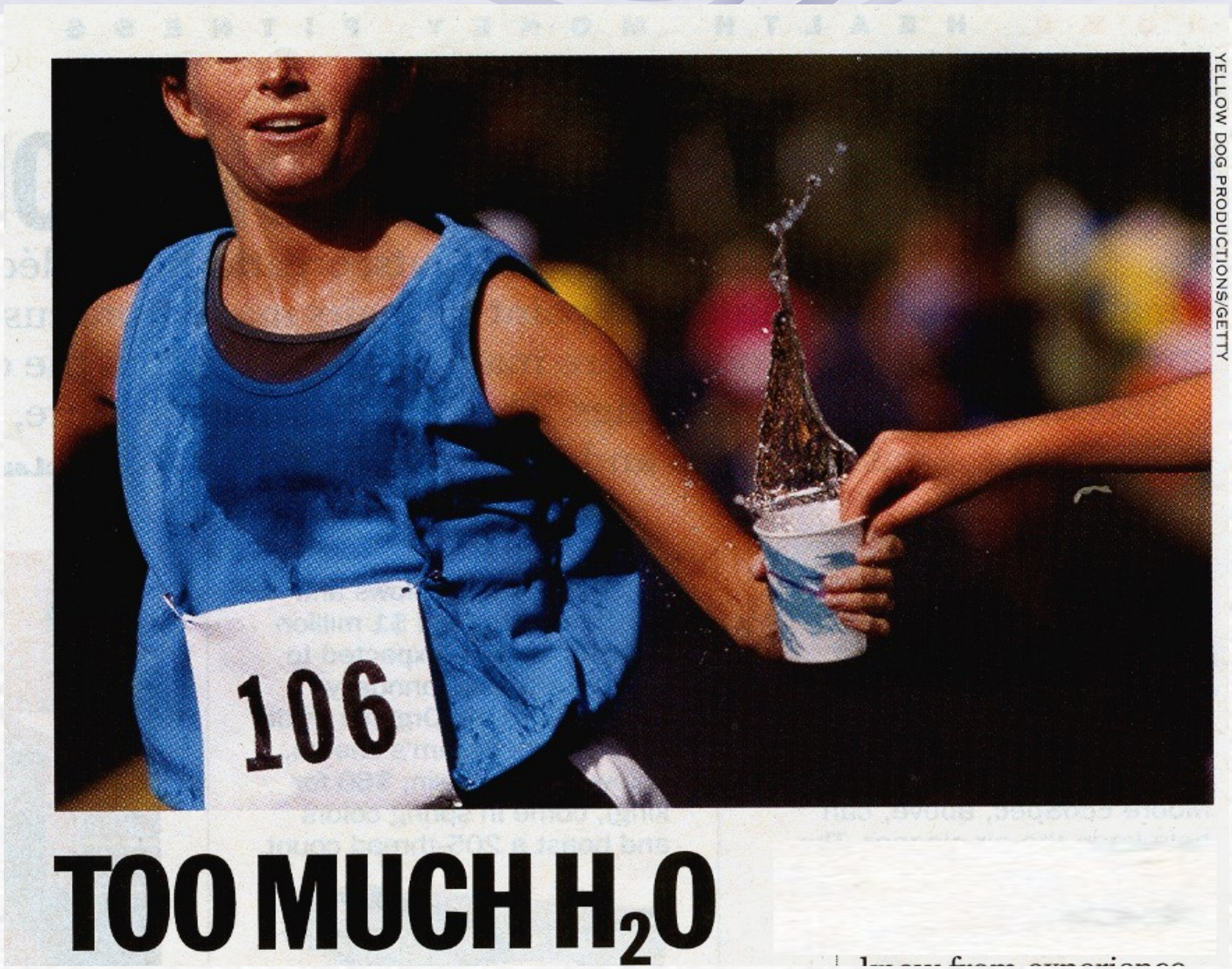
But water comes from other beverages
ie, juice, milk, coffee, soft drinks etc
as well as foods – ie fruits and vegetables

Requirement depends on environment, genetics, physical activity level, etc

Table 1 **Ranges of water content for selected foods.**

Percentage	Food item
100%	Water
90–99%	Fat-free milk, cantaloupe, strawberries, watermelon, lettuce, cabbage, celery, spinach, pickles, squash (cooked)
80–89%	Fruit juice, yogurt, apples, grapes, oranges, carrots, broccoli (cooked), pears, pineapple
70–79%	Bananas, avocados, cottage cheese, ricotta cheese, potato (baked), corn (cooked), shrimp
60–69%	Pasta, legumes, salmon, ice cream, chicken breast
50–59%	Ground beef, hot dogs, feta cheese, tenderloin steak (cooked)
40–49%	Pizza
30–39%	Cheddar cheese, bagels, bread
20–29%	Pepperoni sausage, cake, biscuits
10–19%	Butter, margarine, raisins
1–9%	Walnuts, peanuts (dry roasted), chocolate chip cookies, crackers, cereals, pretzels, taco shells, peanut butter
0%	Oils, sugars

Data from the USDA national nutrient database for standard reference, release 21, as provided in Altman.[126]



2% increase in body water can result in severe cerebral edema

`Water intoxication' kills radio contestant

Tried to consume as much as possible without urinating in bid for video game

January 15, 2007

SACRAMENTO, Calif.–A woman who competed in a radio station's contest to see how much water she could drink without going to the bathroom died of water intoxication, the coroner's office said Saturday.

Jennifer Strange, 28, was found dead Friday in her suburban Rancho Cordova home hours after taking part in the "Hold Your Wee for a Wii" contest in which KDND 107.9 promised a Nintendo Wii video game system for the winner.

"She said to one of our supervisors that she was on her way home and her head was hurting her real bad," said Laura Rios, one of Strange's co-workers at Radiological Associates of Sacramento. "She was crying and that was the last that anyone had heard from her.''

Initially, contestants were handed eight-ounce bottles of water (equivalent to about 237 ml) to drink every 15 minutes.

"They were small little half-pint bottles, so we thought it was going to be easy," said fellow contestant James Ybarra of Woodland. "They told us if you don't feel like you can do this, don't put your health at risk.''

Water as an Economic Factor

While water in developed countries is abundant and cheap much of the world's population has inadequate supply. A global water crisis may be THE major issue of the 21st Century.

Per capita water consumption in the US is 69.3 gal/day:

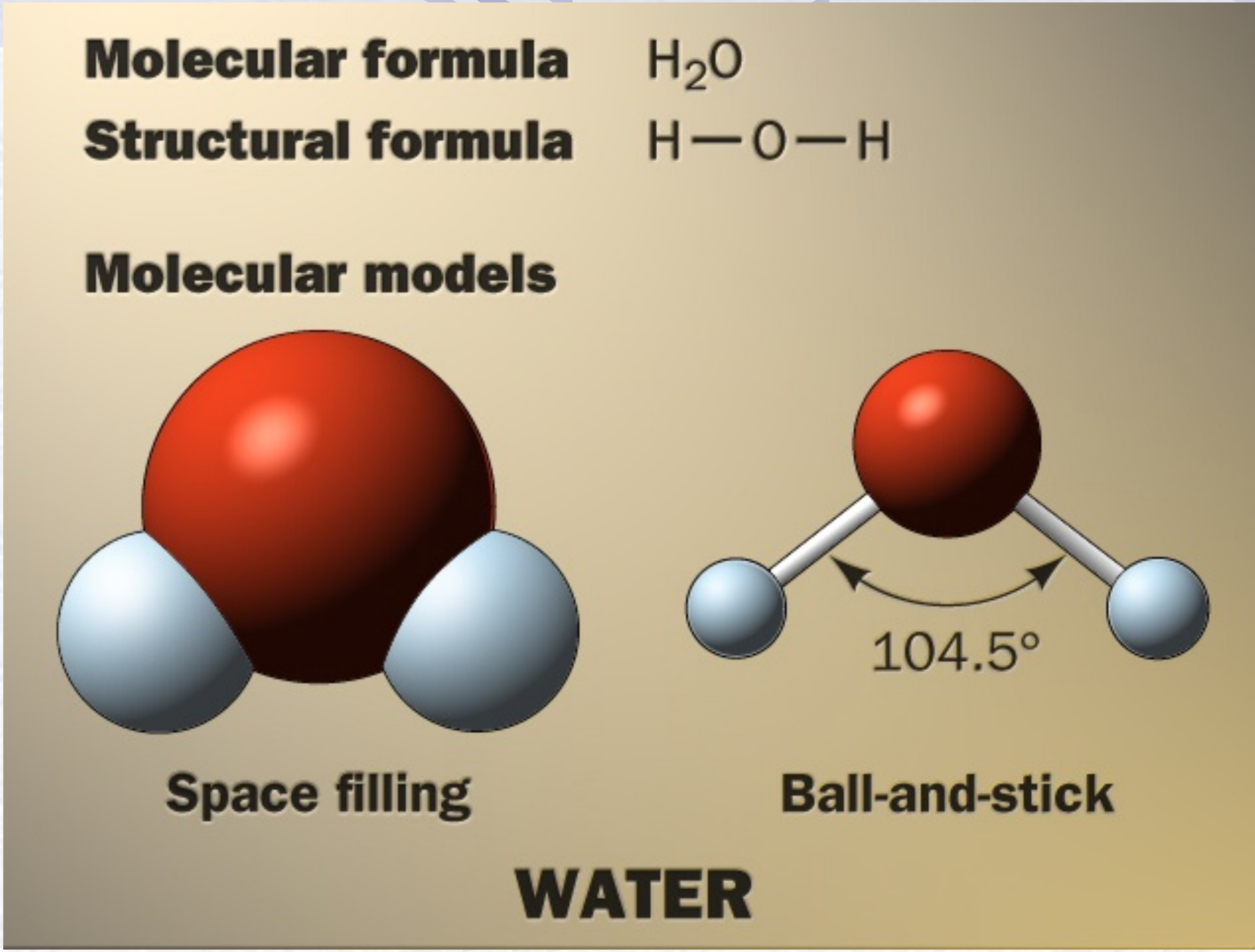
Use	% Total Use	Use	% Total Use
Toilets	26.7	Clothes Washer	21.7
Showers	16.8	Faucets	15.7
Leaks	13.7	Other Domestic	2.2
Baths	1.7	Dishwashers	1.4

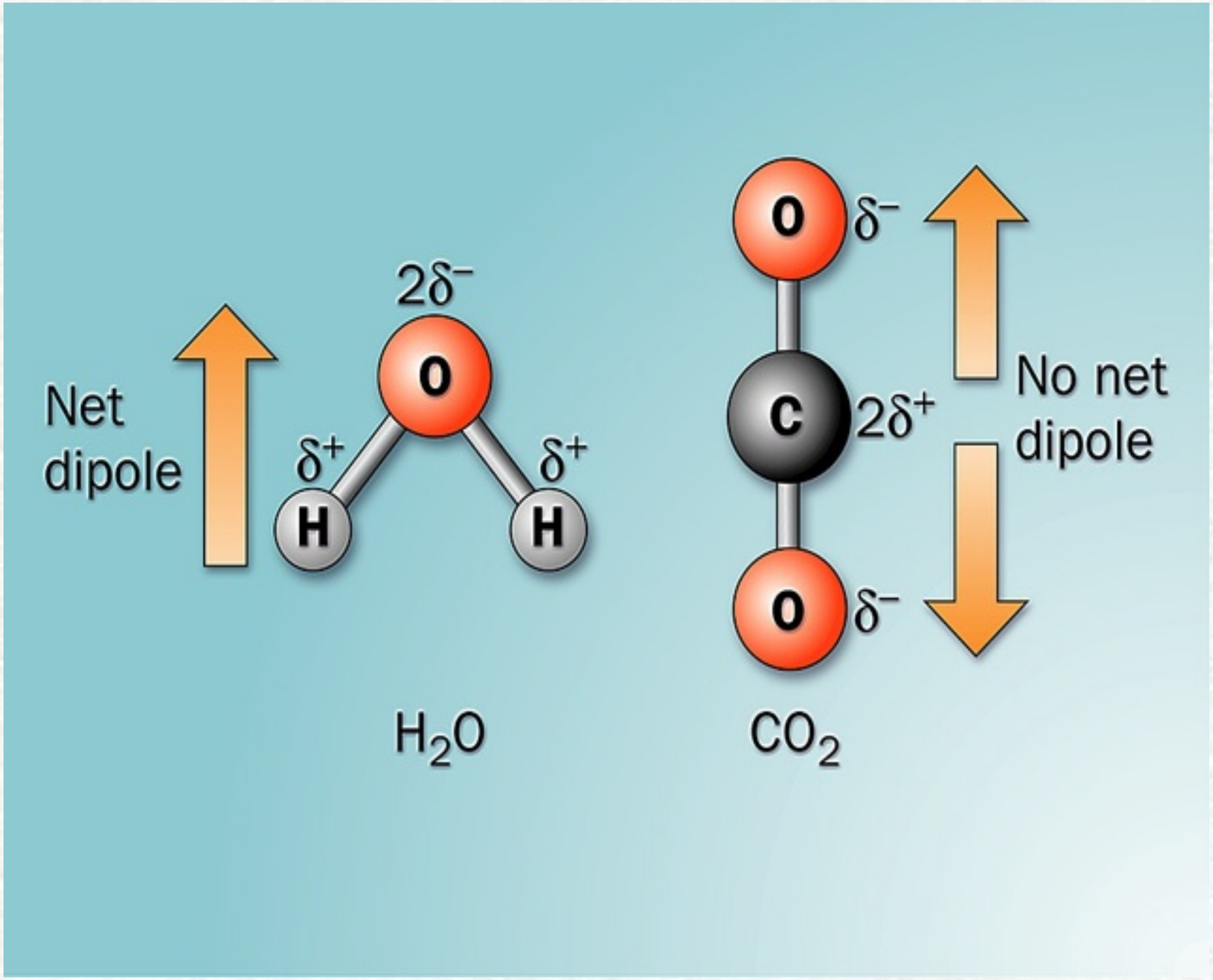
Bottled water is also of major economic importance with spending of $21 billion for 8.4 billion gal by Americans in 2009-10.

TABLE 2–1 Melting Point, Boiling Point, and Heat of Vaporization of Some Common Solvents

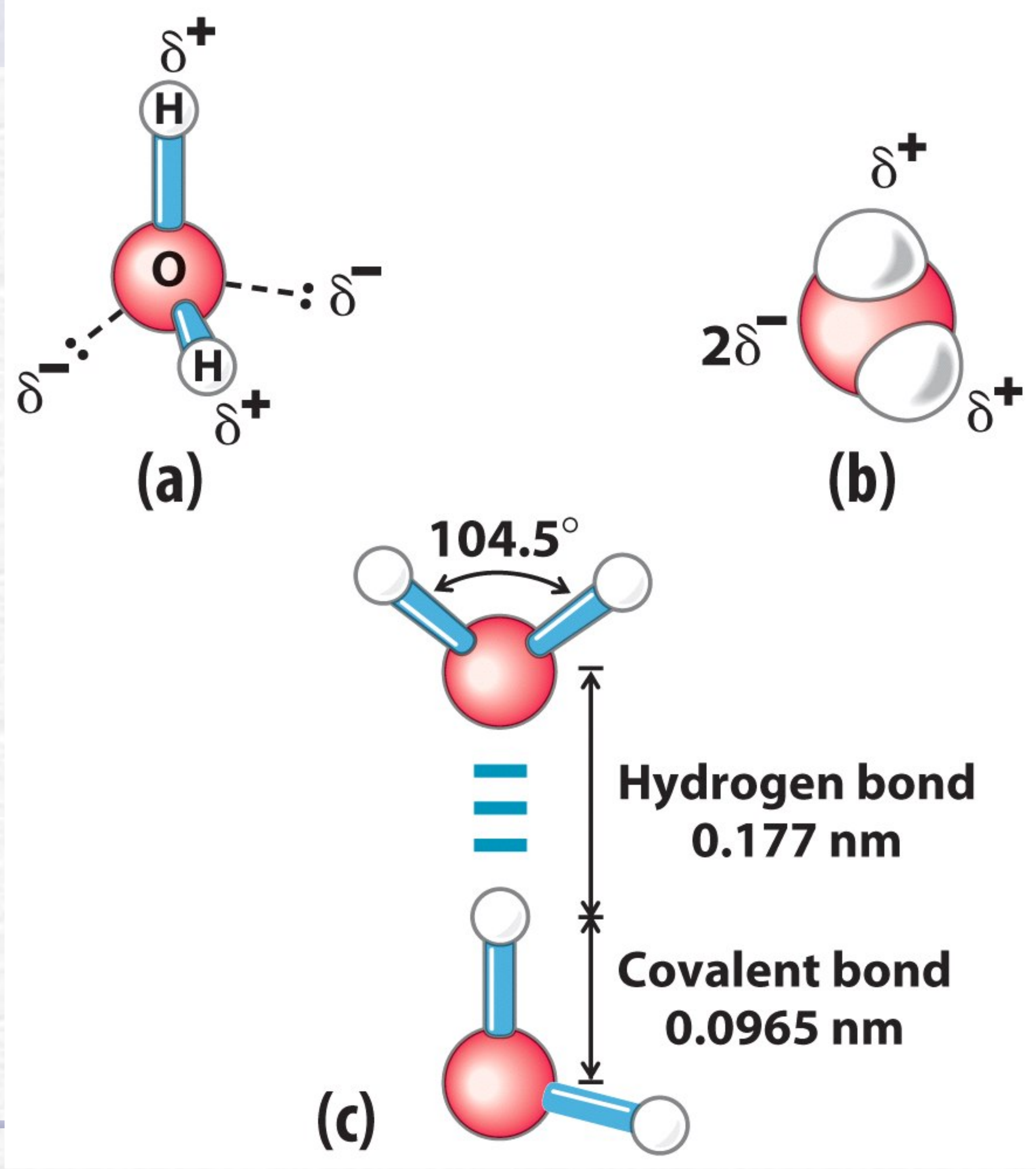
	Melting point (°C)	*Boiling point (°C)*	*Heat of vaporization (J/g)**
Water	0	100	2,260
Methanol (CH_3OH)	−98	65	1,100
Ethanol (CH_3CH_2OH)	−117	78	854
Propanol ($CH_3CH_2CH_2OH$)	−127	97	687
Butanol ($CH_3(CH_2)_2CH_2OH$)	−90	117	590
Acetone (CH_3COCH_3)	−95	56	523
Hexane ($CH_3(CH_2)_4CH_3$)	−98	69	423
Benzene (C_6H_6)	6	80	394
Butane ($CH_3(CH_2)_2CH_3$)	−135	−0.5	381
Chloroform ($CHCl_3$)	−63	61	247

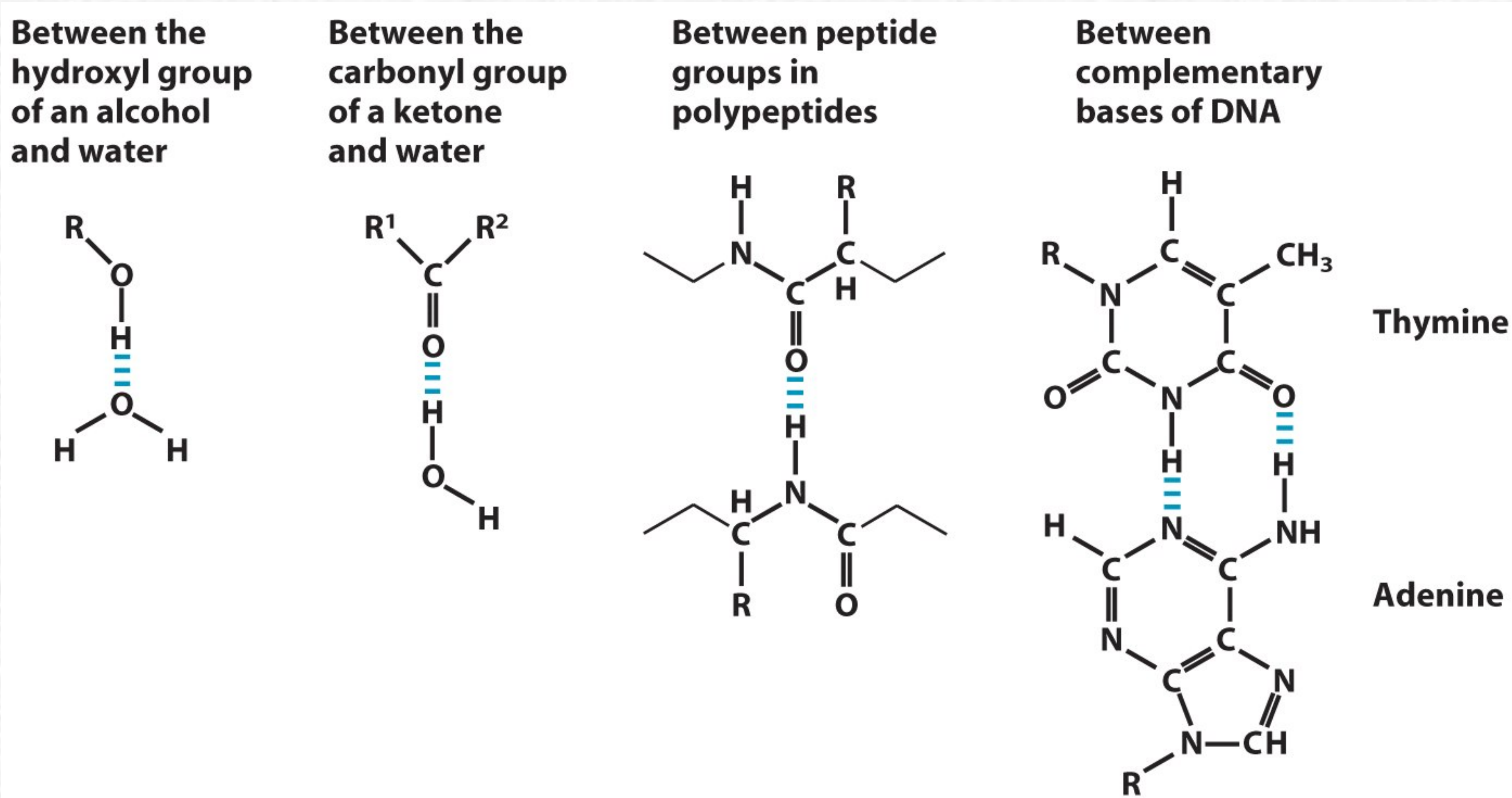
*The heat energy required to convert 1.0 g of a liquid at its boiling point, at atmospheric pressure, into its gaseous state at the same temperature. It is a direct measure of the energy required to overcome attractive forces between molecules in the liquid phase.

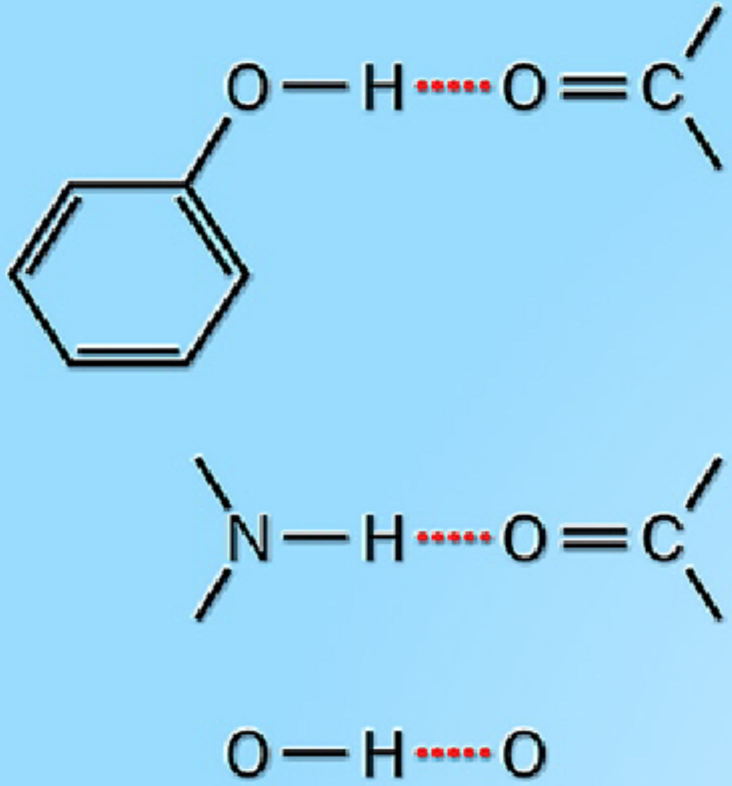

Molecular formula H_2O
Structural formula H—O—H
Molecular models
104.5°
Space filling
Ball-and-stick
WATER



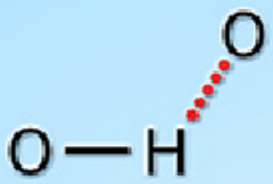
2δ⁻
Net
dipole
δ⁺
δ⁺
O
H
H
H_2O
O
δ⁻
C
2δ⁺
O
δ⁻
No net
dipole
CO_2


δ+
H
O
δ−
δ−
H
δ+
(a)
δ+
2δ−
δ+
(b)
104.5°
Hydrogen bond
0.177 nm
Covalent bond
0.0965 nm
(c)

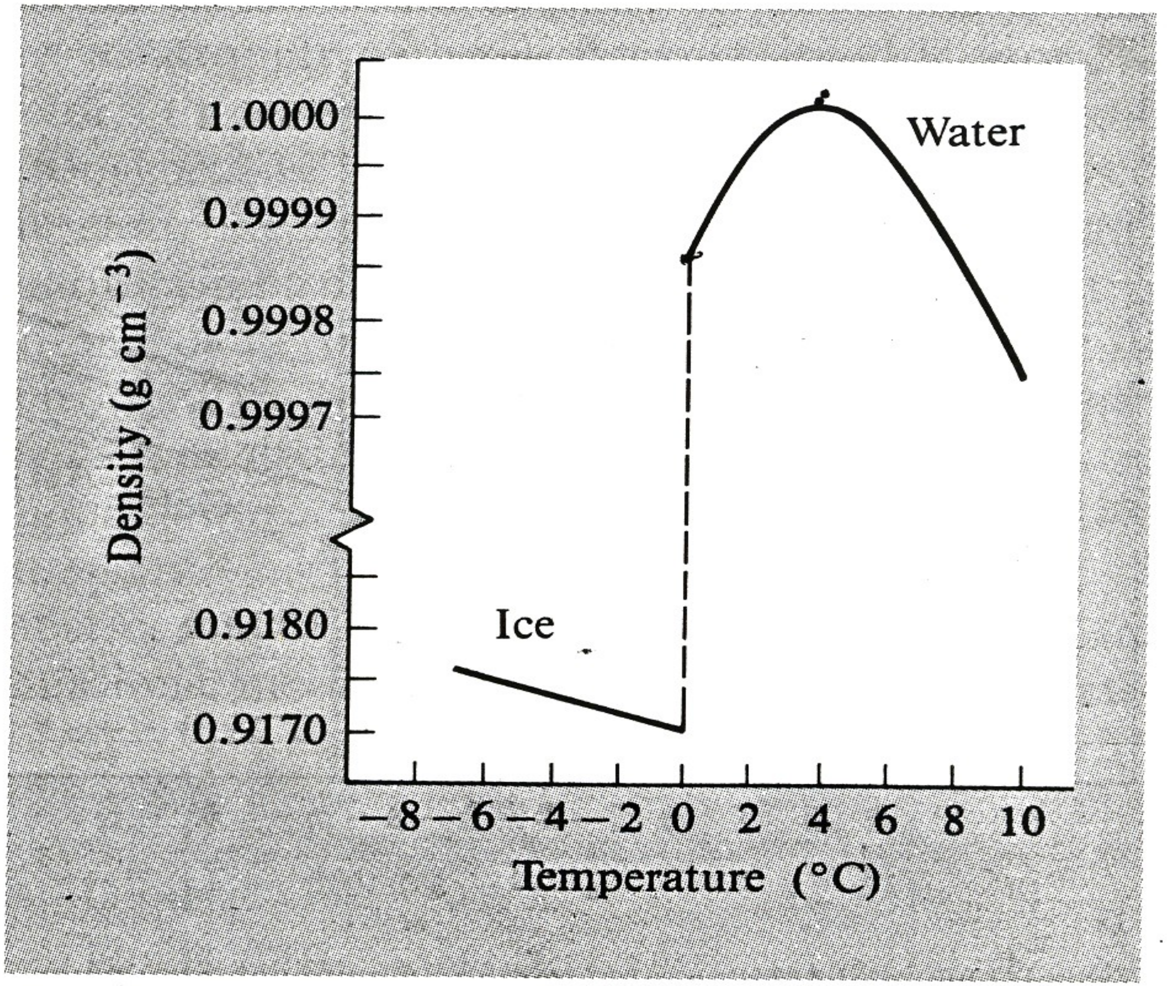

Between the hydroxyl group of an alcohol and water
Between the carbonyl group of a ketone and water
Between peptide groups in polypeptides
Between complementary bases of DNA
Thymine
Adenine



Strong hydrogen bonds



Weak hydrogen bond



1.0000
0.9999
0.9998
0.9997
0.9180
0.9170
Density (g cm^{-3})
Water
Ice
−8 −6 −4 −2 0 2 4 6 8 10
Temperature (°C)

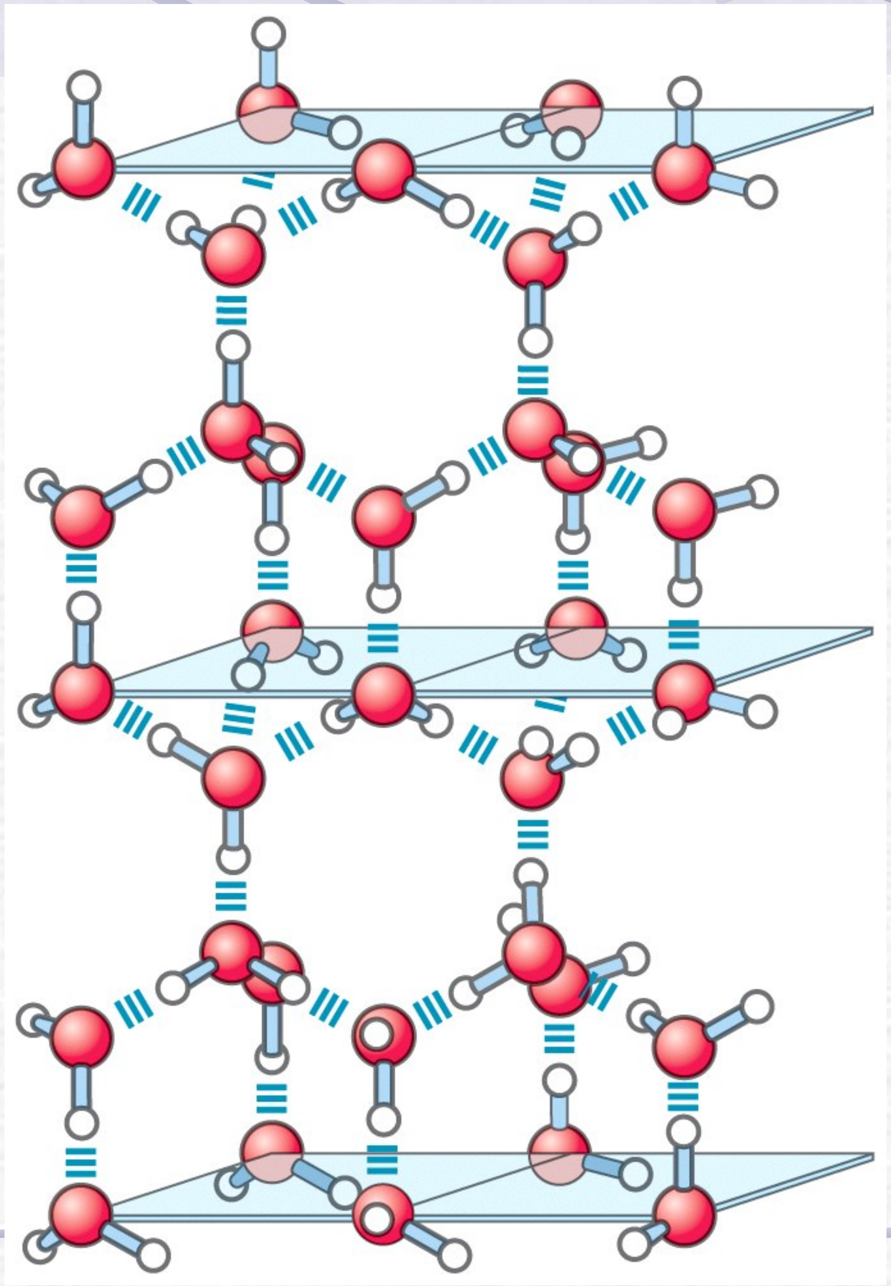
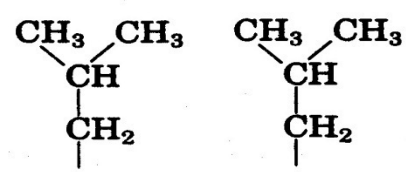
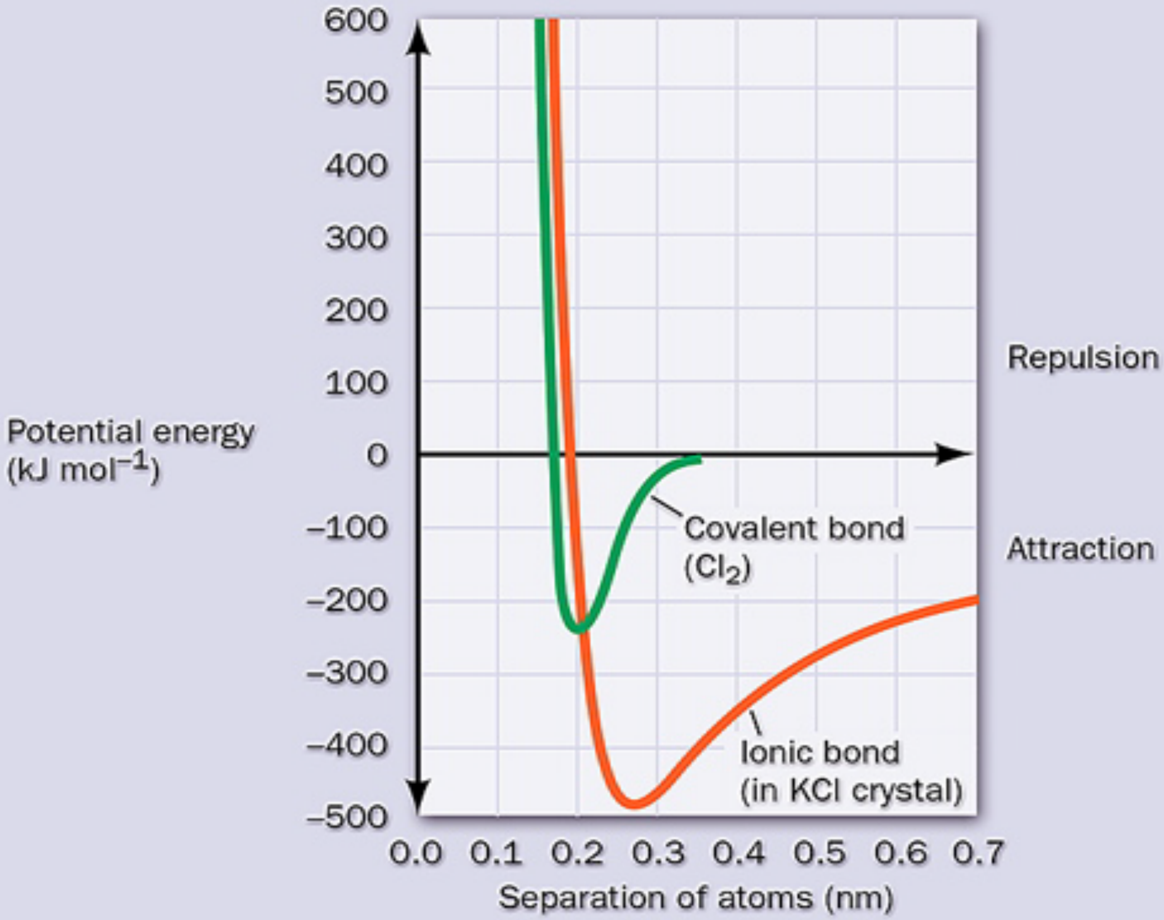
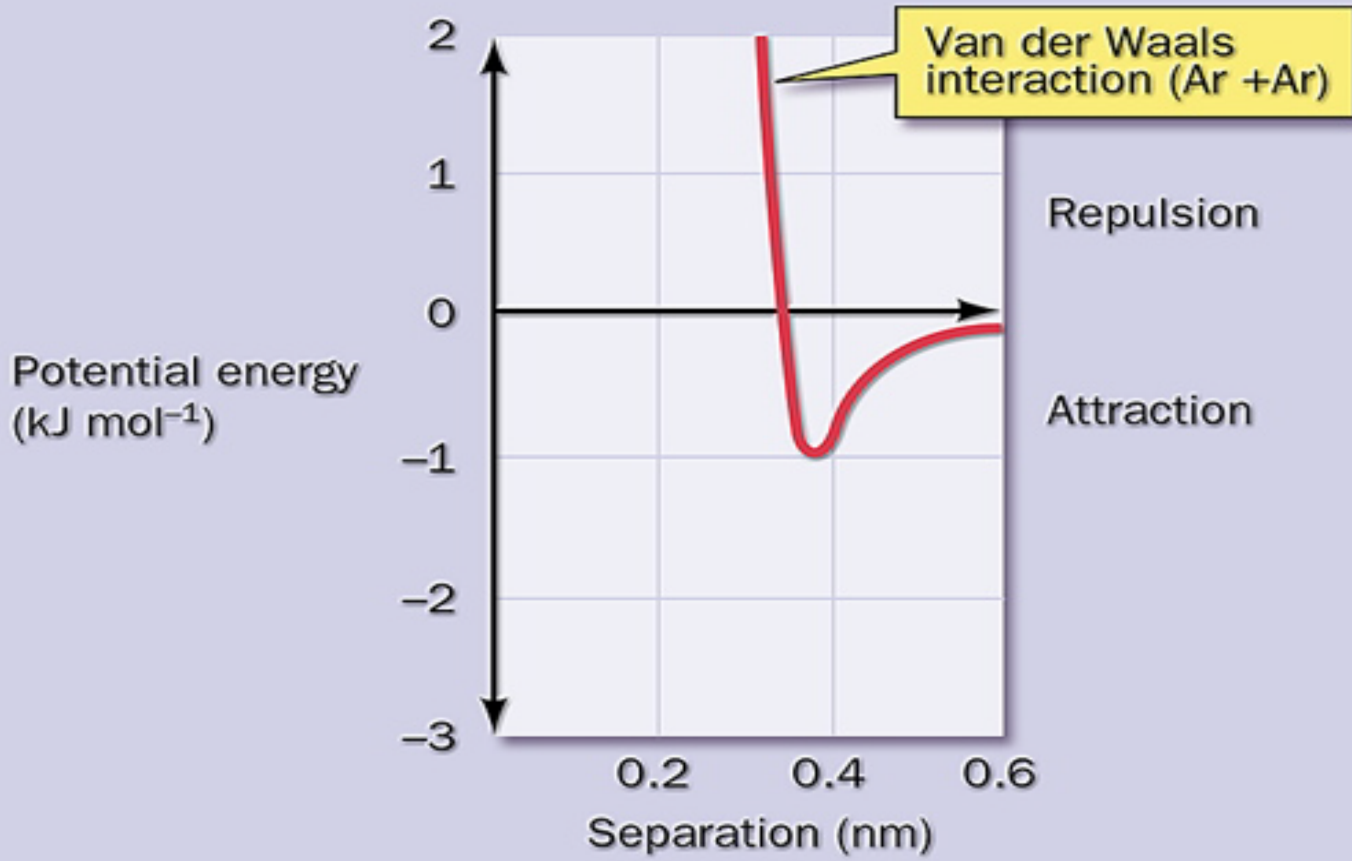


Table 4–4 Four weak interactions among biomolecules in aqueous solvent

Weak interaction		Stabilization energy (kJ/mol)
Hydrogen bonds		
Between neutral groups	$>C{=}O \cdots H{-}O{-}$	8–21
Between peptide bonds	$>C{=}O \cdots H{-}N<$	8–21
Ionic interactions		
Attraction	$-{}^{+}NH_3 \rightarrow\leftarrow {}^{-}O{-}\overset{\overset{\displaystyle O}{\|}}{C}{-}$	42
Repulsion	$-{}^{+}NH_3 \longleftrightarrow H_3N^{+}-$	≈−21
Hydrophobic interactions		4–8
van der Waals interactions	Any two atoms in close proximity	4



Electrostatic Interactions



Van der Waals Interaction

COULOMB' S LAW

$$F = \frac{Kq_1q_2}{Dr^2}$$

F = force between two electronic charges (q_1q_2)

D = dielectric constant

K = proportionality constant

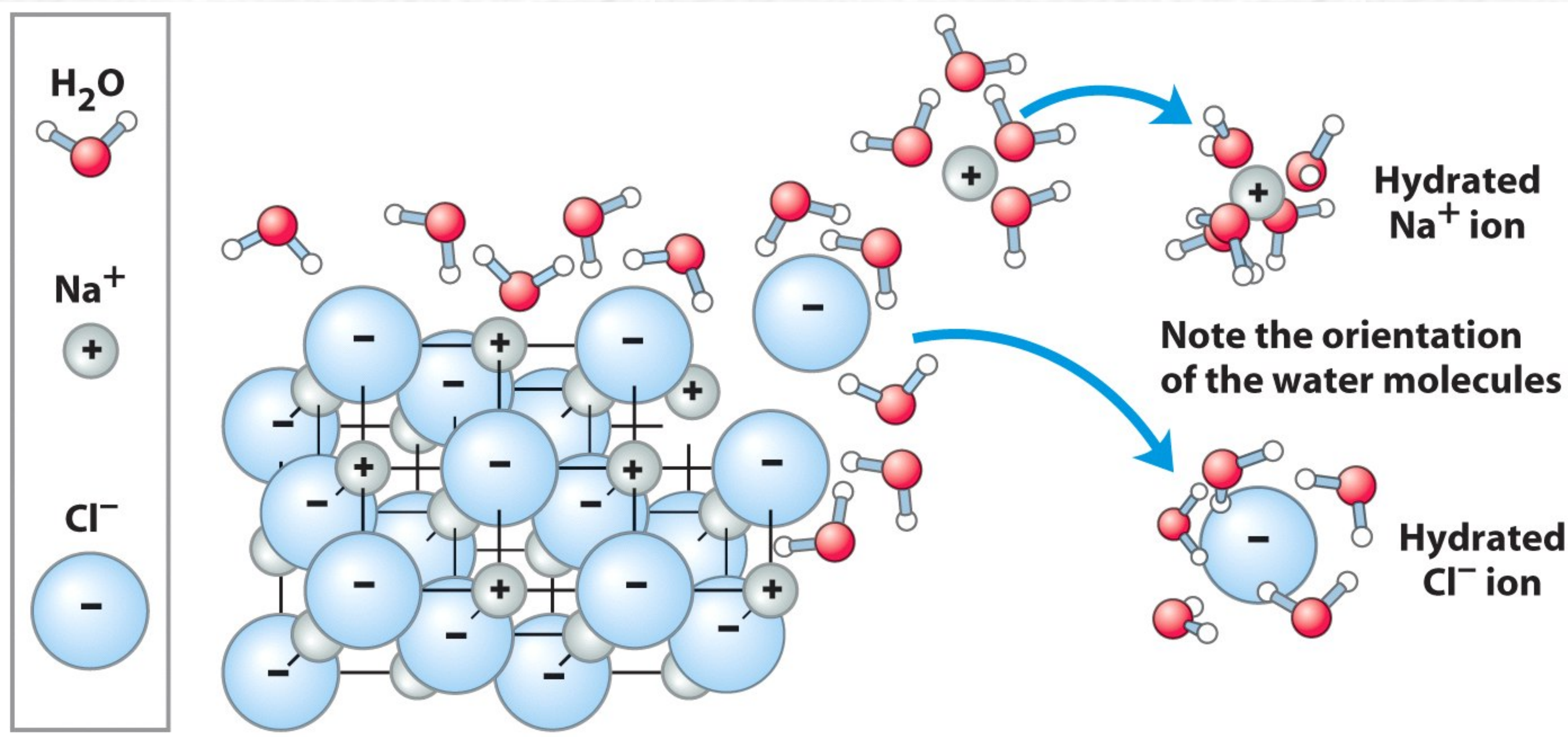
R = distance

Table 2-1

Dielectric Constants and Permanent Molecular Dipole Moments of Some Common Solvents

Substance	Dielectric Constant	Dipole Moment (debye)
Formamide	110.0	3.37
Water	78.5	1.85
Dimethyl sulfoxide	48.9	3.96
Methanol	32.6	1.66
Ethanol	24.3	1.68
Acetone	20.7	2.72
Ammonia	16.9	1.47
Chloroform	4.8	1.15
Diethyl ether	4.3	1.15
Benzene	2.3	0.00
Carbon tetrachloride	2.2	0.00
Hexane	1.9	0.00

Source: Brey, W. S., *Physical Chemistry and Its Biological Applications*, p. 26, Academic Press (1978).

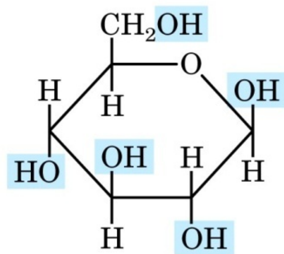


H_2O
Na^+
Cl^-
Hydrated Na^+ ion
Note the orientation of the water molecules
Hydrated Cl^- ion

TABLE 2–2 Some Examples of Polar, Nonpolar, and Amphipathic Biomolecules (Shown as Ionic Forms at pH 7)

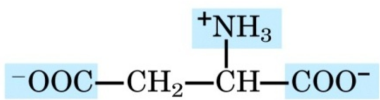
Polar

Glucose

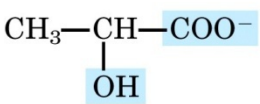


Glycine $^{+}NH_3-CH_2-COO^-$

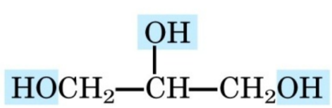
Aspartate



Lactate

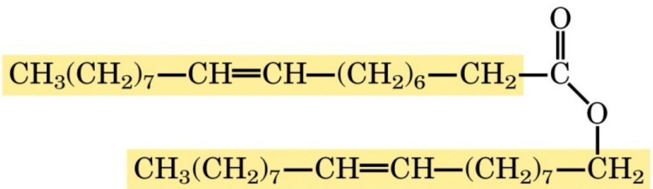


Glycerol



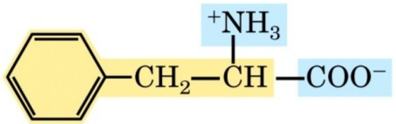
Nonpolar

Typical wax

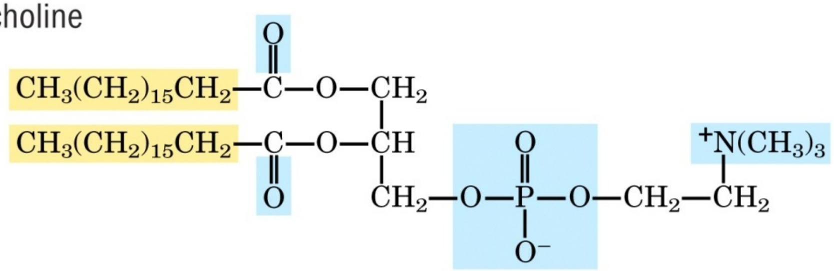


Amphipathic

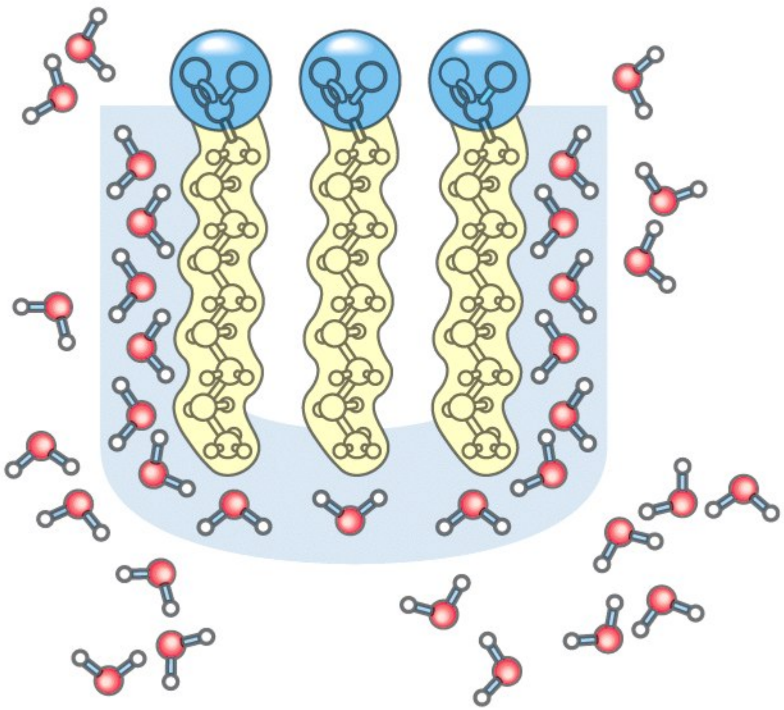
Phenylalanine



Phosphatidylcholine

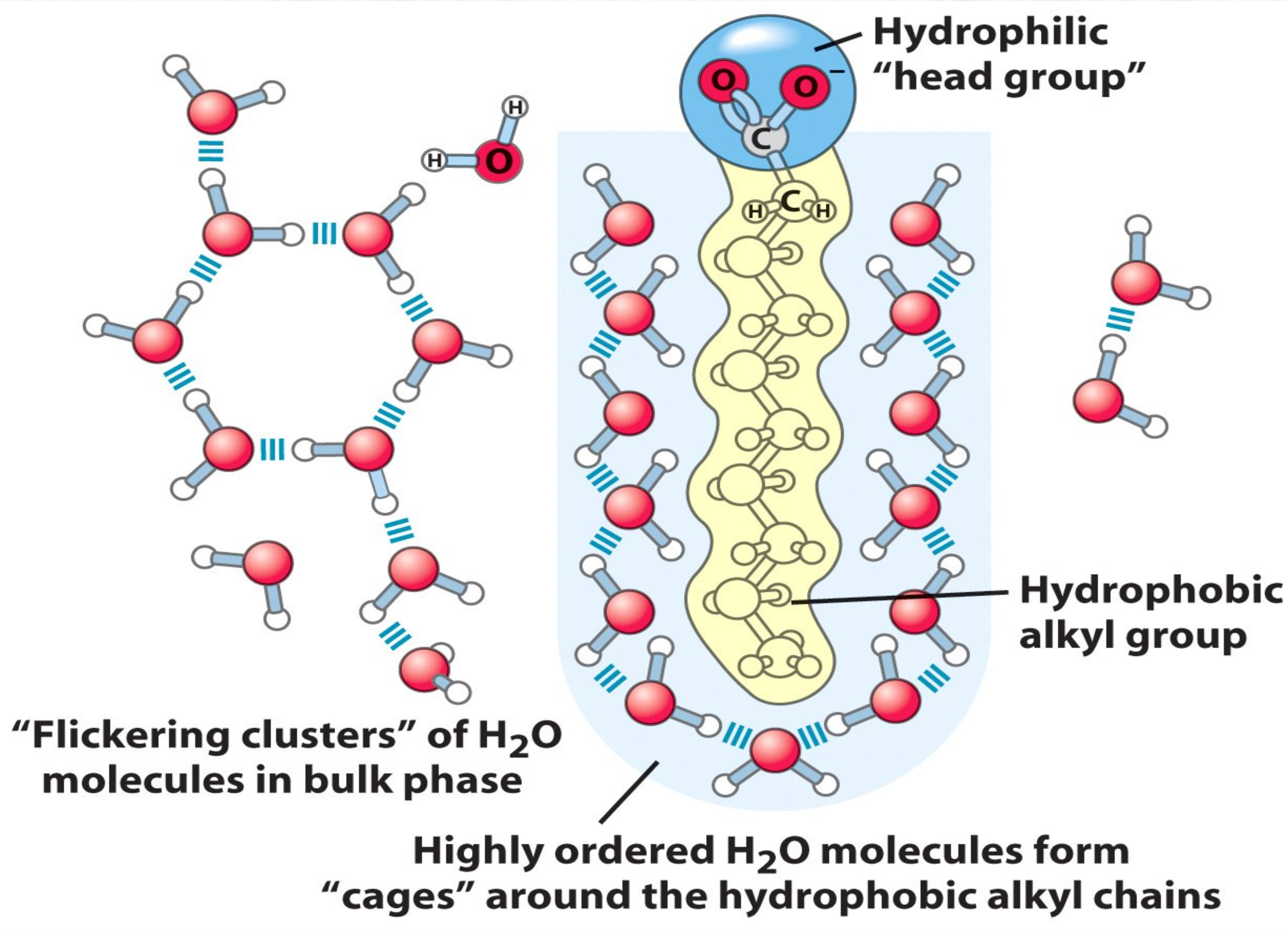


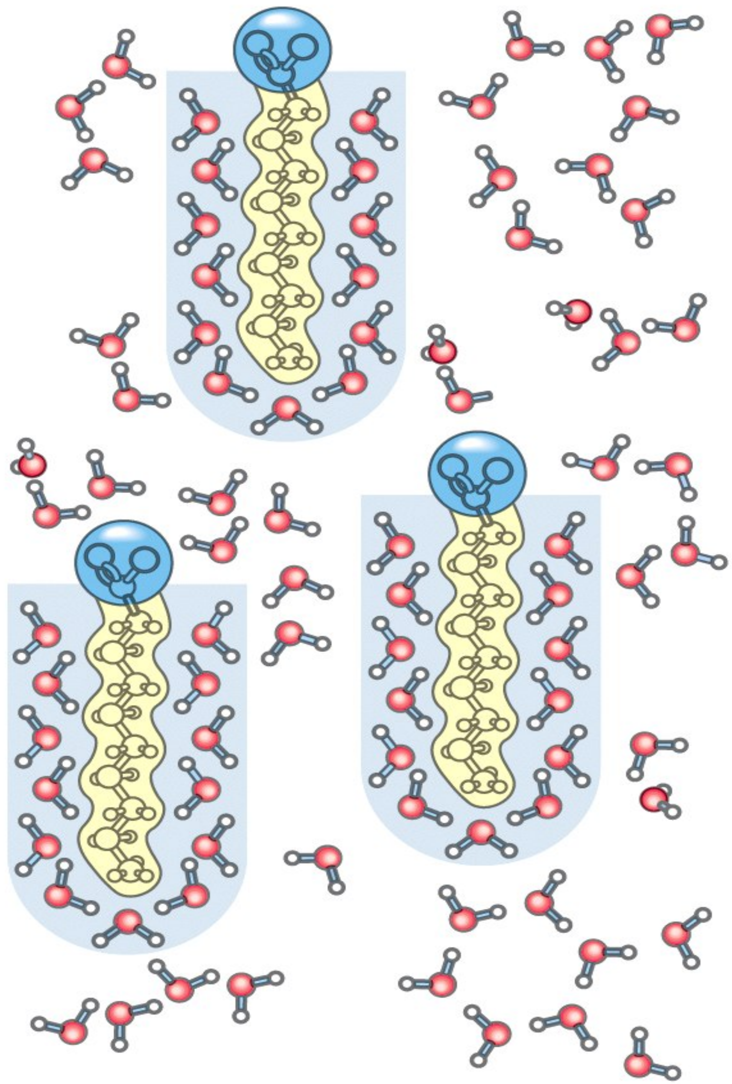
Polar groups Nonpolar groups



Clusters of lipid molecules

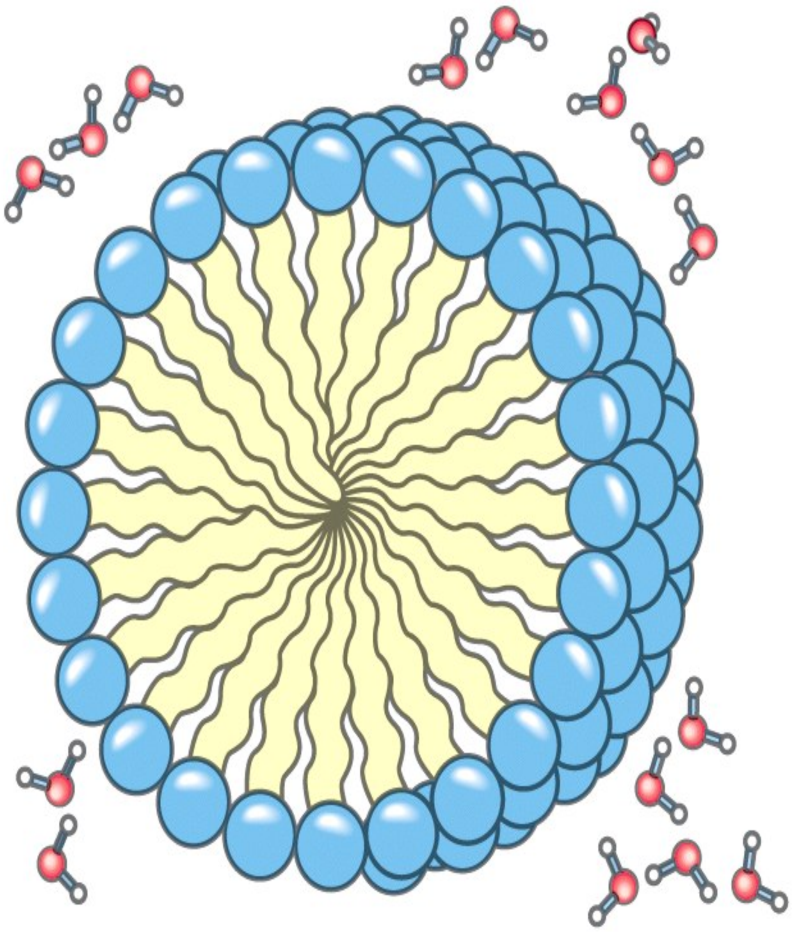
Only lipid portions at the edge of the cluster force the ordering of water. Fewer H_2O molecules are ordered, and entropy is increased.


Hydrophilic
"head group"
O
O
C
H
O
H
C
H
H
Hydrophobic
alkyl group
"Flickering clusters" of H2O
molecules in bulk phase
Highly ordered H2O molecules form
"cages" around the hydrophobic alkyl chains



Dispersion of lipids in H_2O

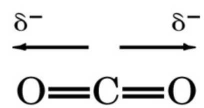
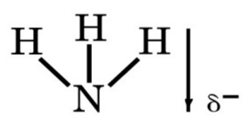
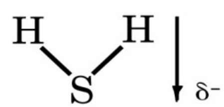
Each lipid molecule forces surrounding H_2O molecules to become highly ordered.



Micelles

All hydrophobic groups are sequestered from water; ordered shell of H_2O molecules is minimized, and entropy is further increased.

TABLE 2–3 Solubilities of Some Gases in Water

Gas	*Structure**	*Polarity*	*Solubility in water (g/L)*†
Nitrogen	N≡N	Nonpolar	0.018 (40 °C)
Oxygen	O═O	Nonpolar	0.035 (50 °C)
Carbon dioxide		Nonpolar	0.97 (45 °C)
Ammonia		Polar	900 (10 °C)
Hydrogen sulfide		Polar	1,860 (40 °C)

*The arrows represent electric dipoles; there is a partial negative charge (δ^-) at the head of the arrow, a partial positive charge (δ^+; not shown here) at the tail.

†Note that polar molecules dissolve far better even at low temperatures than do nonpolar molecules at relatively high temperatures.

Colligative Properties

- Vapor Pressure
- Boiling Point
- Melting (Freezing) Point
- Osmotic Pressure

Depending on the number of solute particles (molecules or ions) in a given amount of solvent expressed in Molal (m) units or $\left(\dfrac{\text{moles of solute}}{\text{1000g solvent}}\right)$

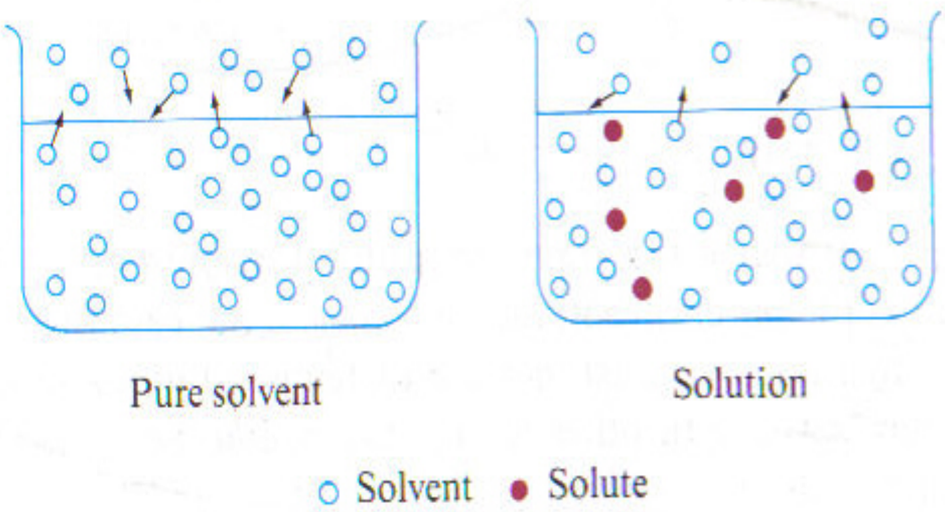
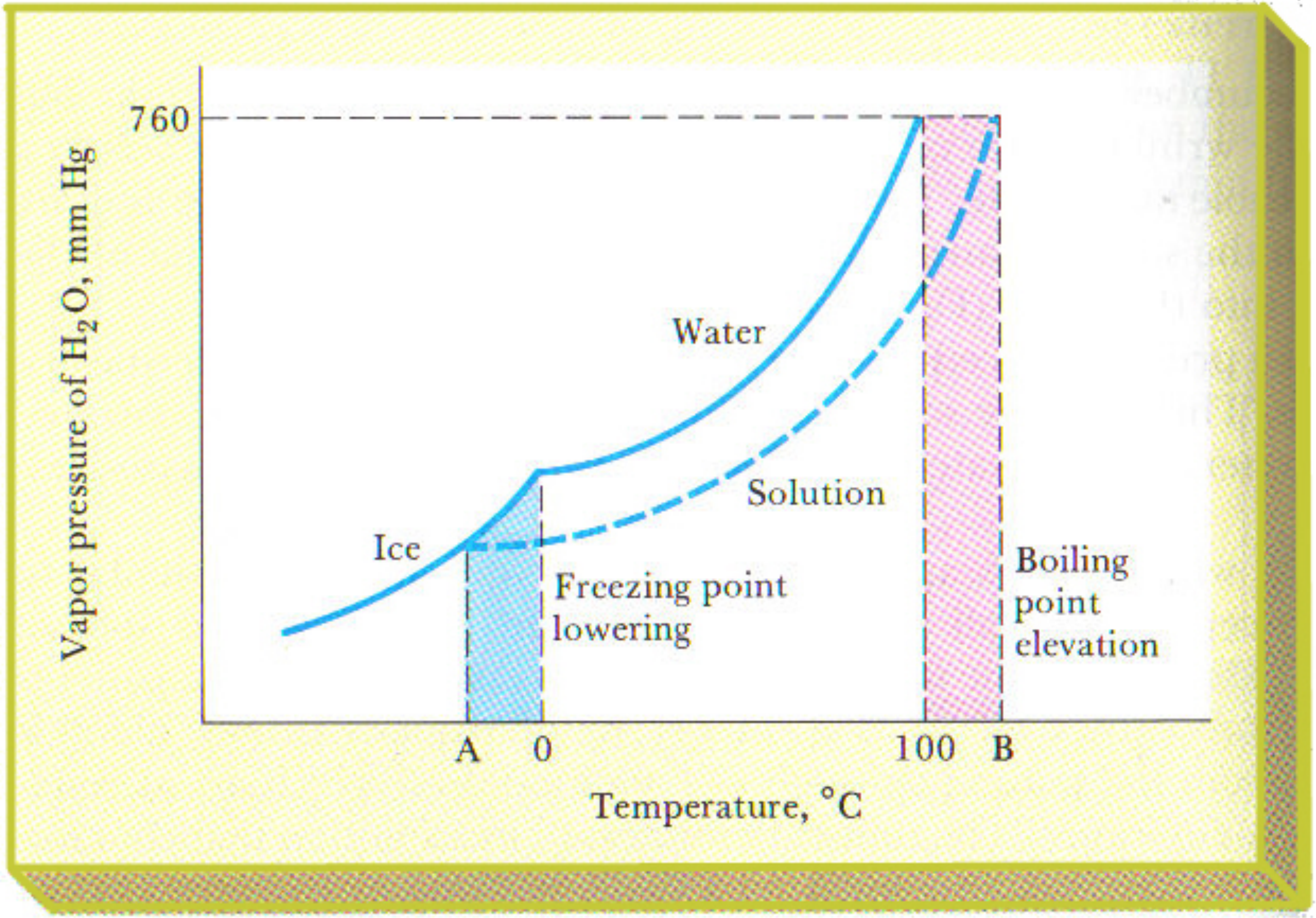


FIGURE 12.22
Vapor Pressure of a Solution.

The vapor pressure of a solution is lower than that of the pure solvent. Fewer molecules escape from the surface of the solution than from the pure solvent in the same time interval.



760
Vapor pressure of H_2O, mm Hg
Water
Solution
Ice
Freezing point lowering
Boiling point elevation
A
0
100
B
Temperature, °C

TABLE 11.4 Molal Freezing Point and Boiling Point Constants

SOLVENT	fp (°C)	k_f (°C/m)	bp (°C)	k_b (°C/m)
Water	0.00	1.86	100.00	0.52
Acetic acid	16.66	3.90	117.90	2.53
Benzene	5.50	5.10	80.10	2.53
Cyclohexane	6.50	20.2	80.72	2.75
Camphor	178.40	40.0	207.42	5.61
p-Dichlorobenzene	53.1	7.1	174.1	6.2
Naphthalene	80.29	6.94	217.96	5.80

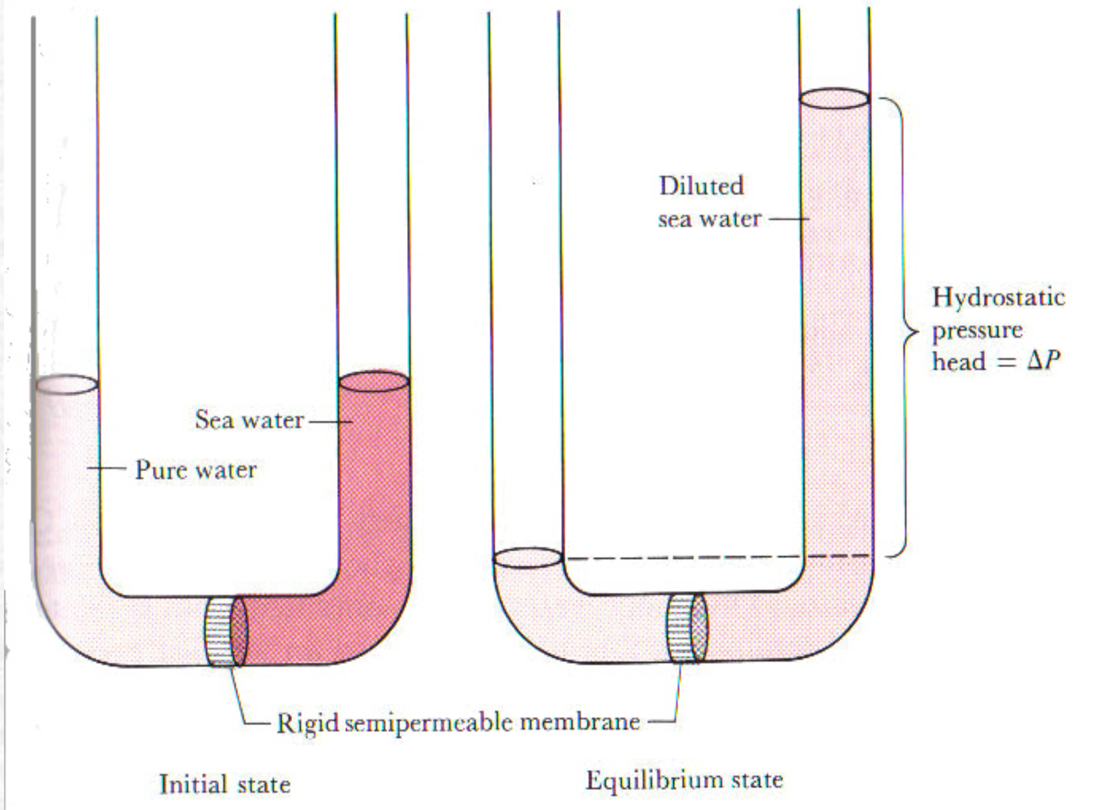
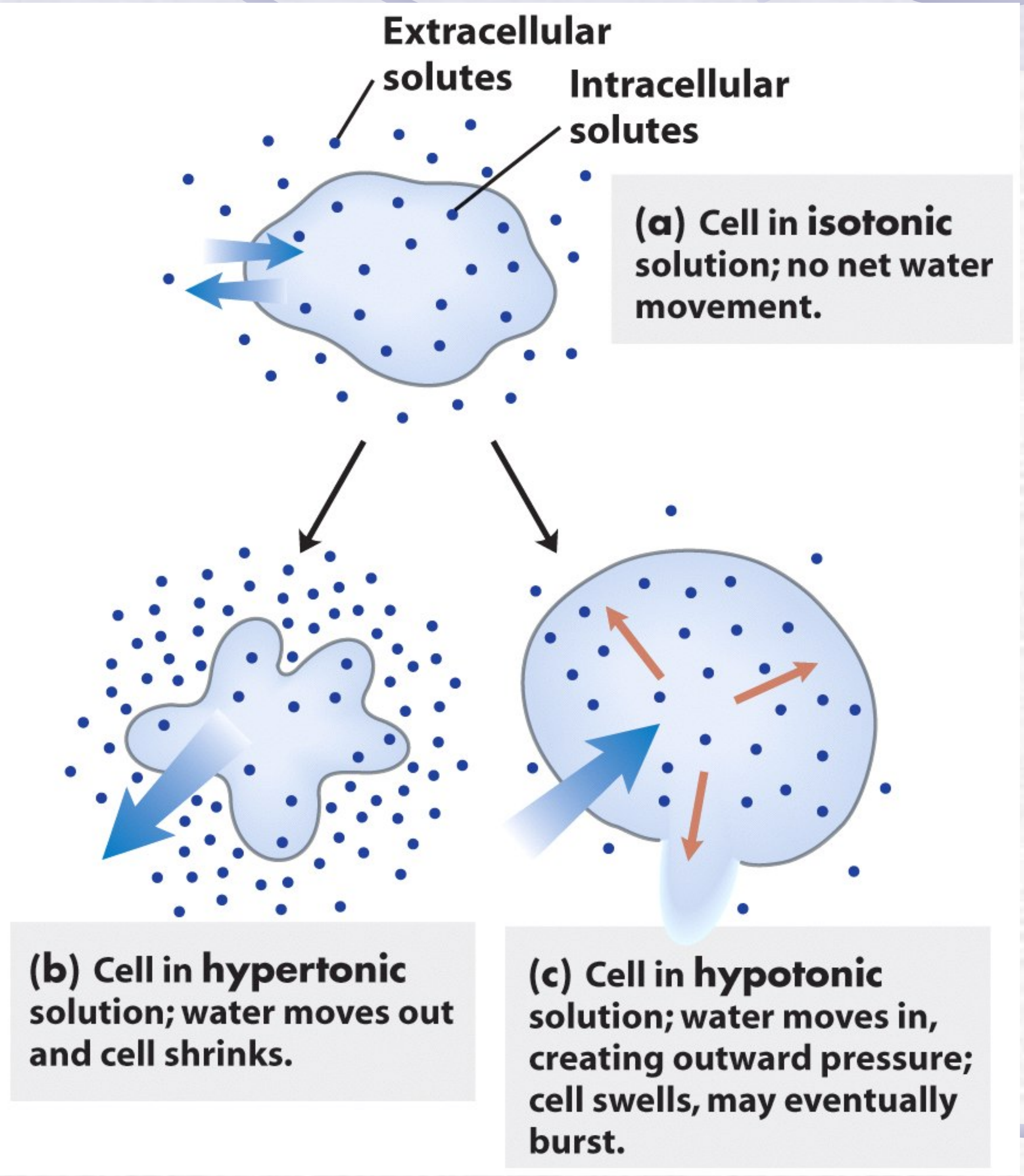
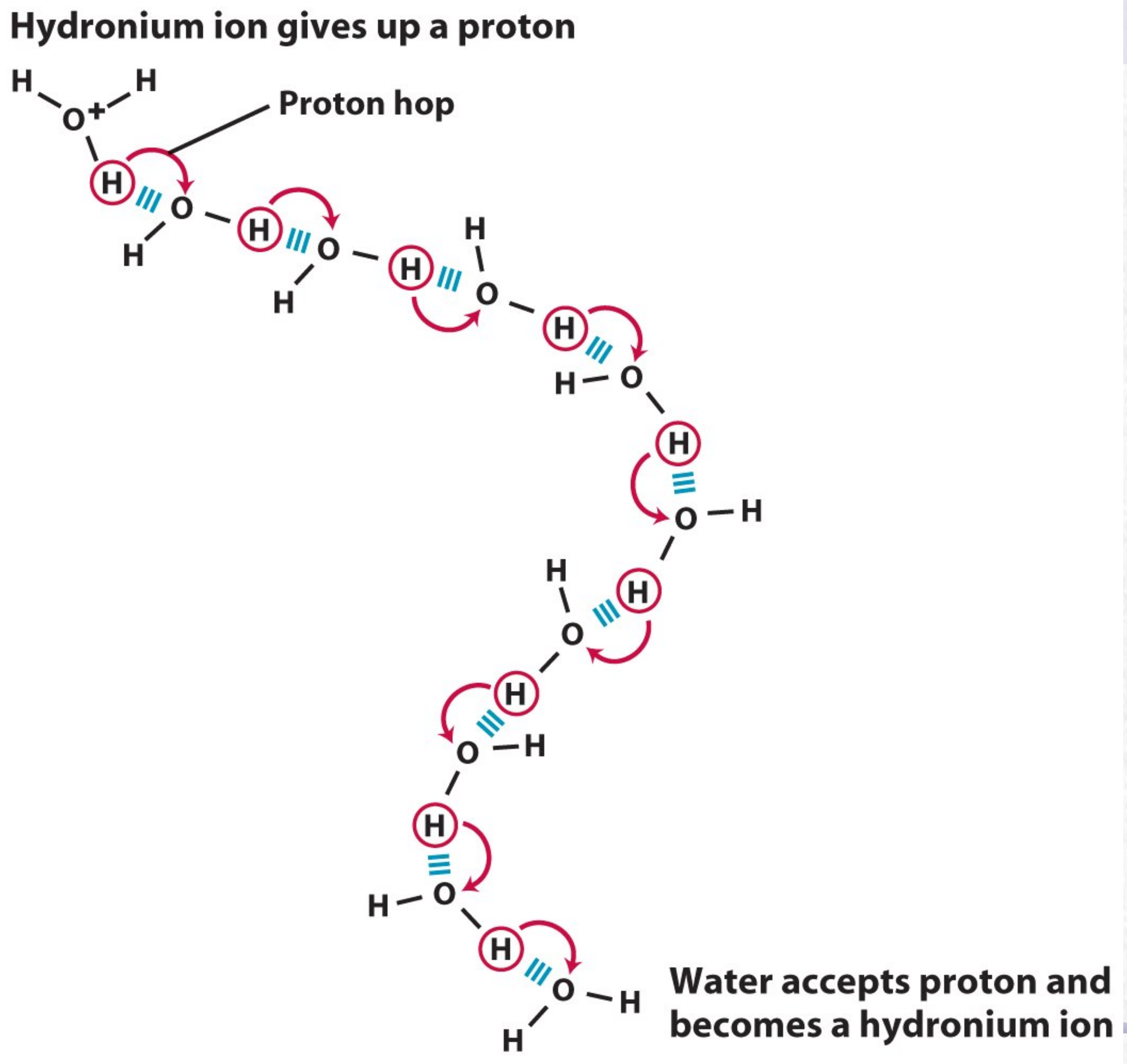


Figure 14-12 Passage of water through a rigid semipermeable membrane separating pure water from seawater. The water passes through the membrane until the escaping tendency of the pure water equals the escaping tendency of the water from the seawater. The escaping tendency of water from the seawater side of the membrane increases as the seawater is diluted and as a result of the increased hydrostatic pressure head on the seawater, which results from the increase in the seawater column height.


Extracellular solutes
Intracellular solutes
(a) Cell in isotonic solution; no net water movement.
(b) Cell in hypertonic solution; water moves out and cell shrinks.
(c) Cell in hypotonic solution; water moves in, creating outward pressure; cell swells, may eventually burst.

(a) (b)


Hydronium ion gives up a proton
Proton hop
Water accepts proton and becomes a hydronium ion

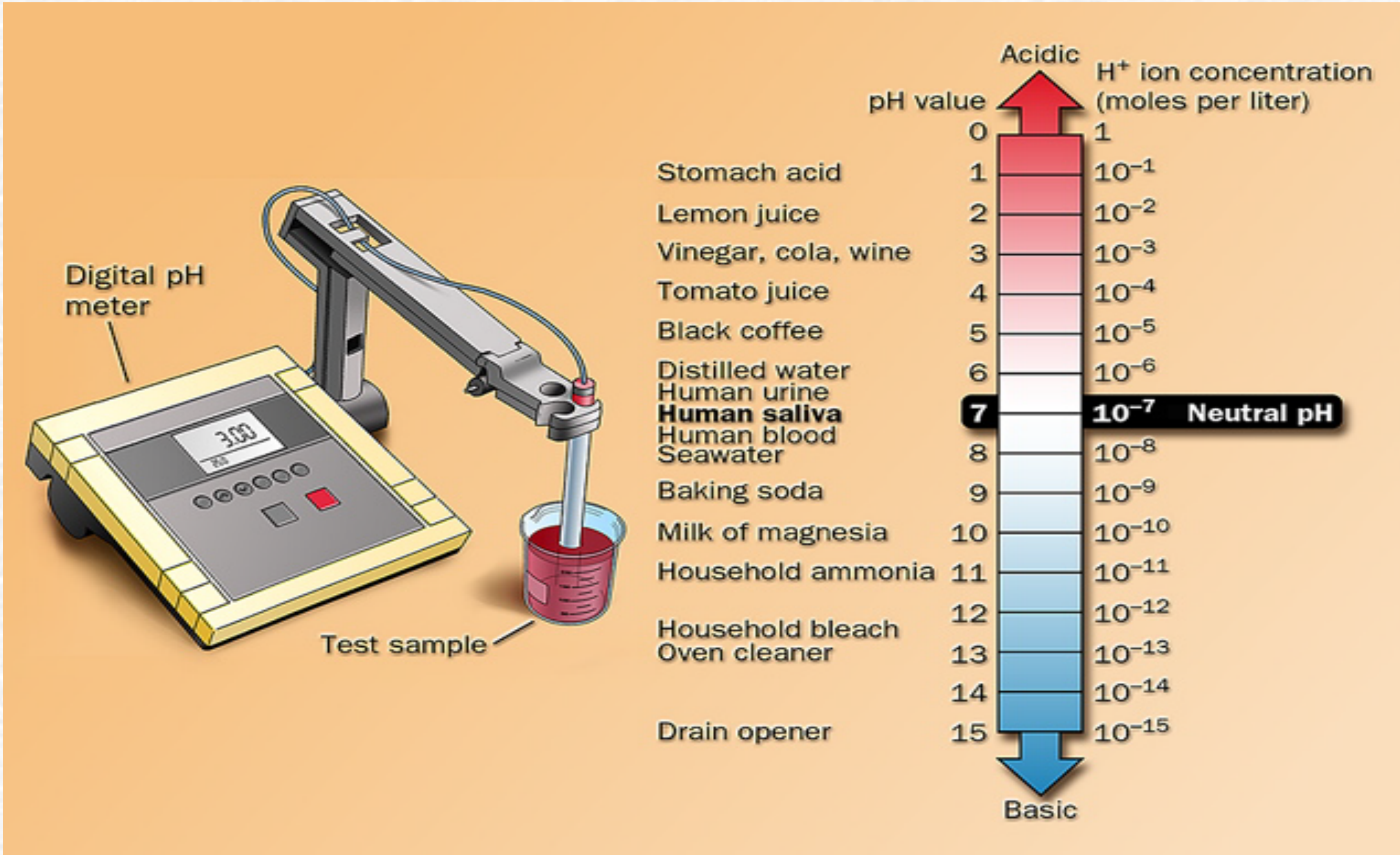
$$pH = -\log[H^+]$$

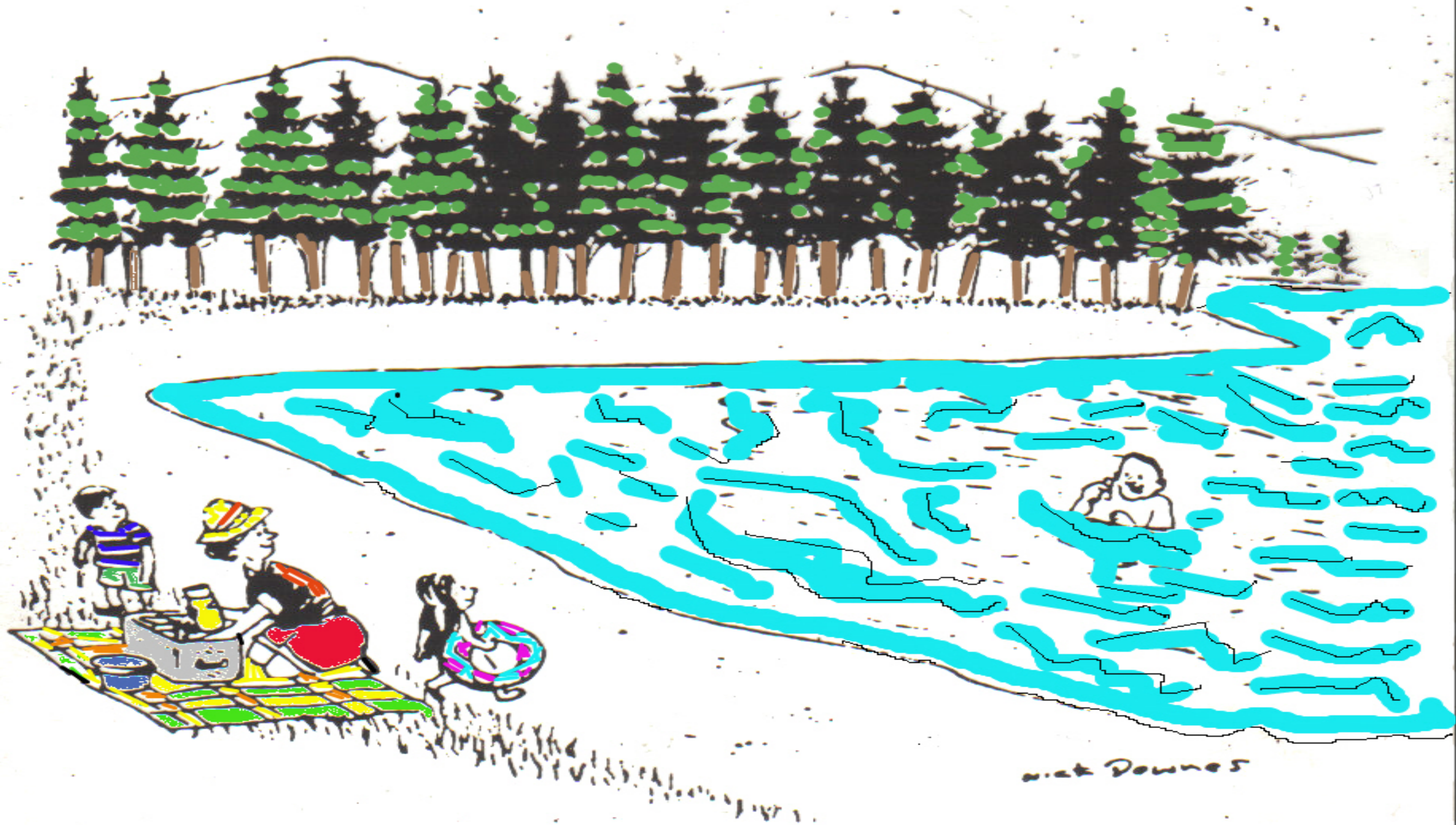
TABLE 2–6	The pH Scale		
$[H^+]$ (M)	pH	$[OH^-]$ (M)	pOH*
10^0 (1)	0	10^{-14}	14
10^{-1}	1	10^{-13}	13
10^{-2}	2	10^{-12}	12
10^{-3}	3	10^{-11}	11
10^{-4}	4	10^{-10}	10
10^{-5}	5	10^{-9}	9
10^{-6}	6	10^{-8}	8
10^{-7}	7	10^{-7}	7
10^{-8}	8	10^{-6}	6
10^{-9}	9	10^{-5}	5
10^{-10}	10	10^{-4}	4
10^{-11}	11	10^{-3}	3
10^{-12}	12	10^{-2}	2
10^{-13}	13	10^{-1}	1
10^{-14}	14	10^0 (1)	0

*The expression pOH is sometimes used to describe the basicity, or OH^- concentration, of a solution; pOH is defined by the expression pOH = $-\log [OH^-]$, which is analogous to the expression for pH. Note that in all cases, pH + pOH = 14.

Table 2-6

Lehninger Principles of Biochemistry, Fifth Edition

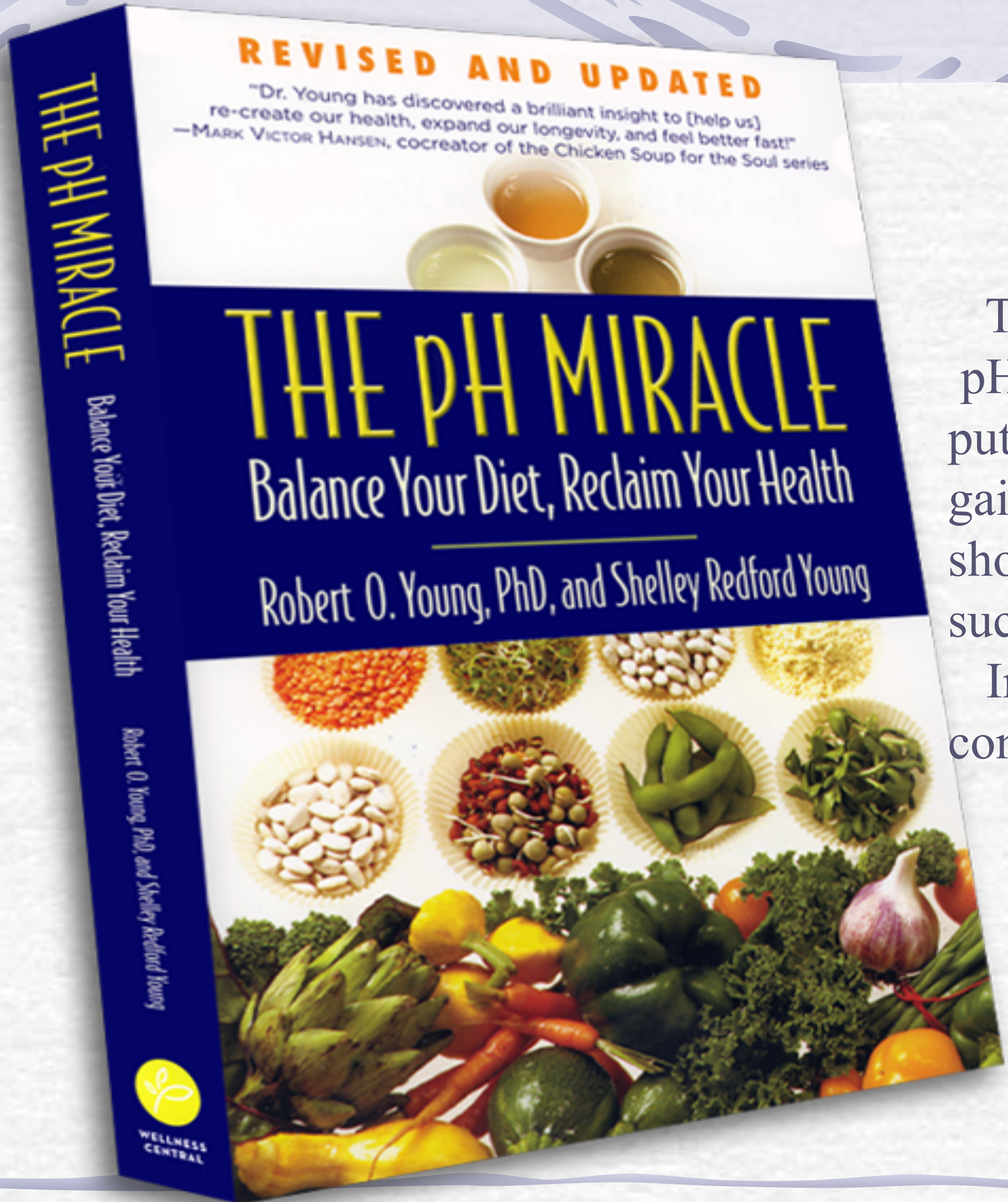

Digital pH meter
Test sample
Acidic
pH value
H+ ion concentration (moles per liter)
0 1
Stomach acid 1 10−1
Lemon juice 2 10−2
Vinegar, cola, wine 3 10−3
Tomato juice 4 10−4
Black coffee 5 10−5
Distilled water 6 10−6
Human urine
Human saliva 7 10−7 Neutral pH
Human blood
Seawater 8 10−8
Baking soda 9 10−9
Milk of magnesia 10 10−10
Household ammonia 11 10−11
12 10−12
Household bleach
Oven cleaner 13 10−13
14 10−14
Drain opener 15 10−15
Basic



"Come on in—the pH is fine!"

Effect of increased global warming – Increased CO_2 dissolved in oceans so pH decreases. Left: 400ppm CO_2; Right:2,850ppm CO_2

Lobsters get bigger but sea urchins get smaller Δ pH = 0.1 unit



This diet claims that foods with low pH values such as meat and dairy put stress on the body, causing wt gain and inflammation so we should consume alkaline -type foods such as green vegetables to keep slim

In reality pH of digested foods is controlled by digestive enzymes..

Two Step Quick Estimate of pH for Strong Acids

i.e. HCl = 0.00035 M

STEP 1: PUT IN EXPONENTIAL FORM

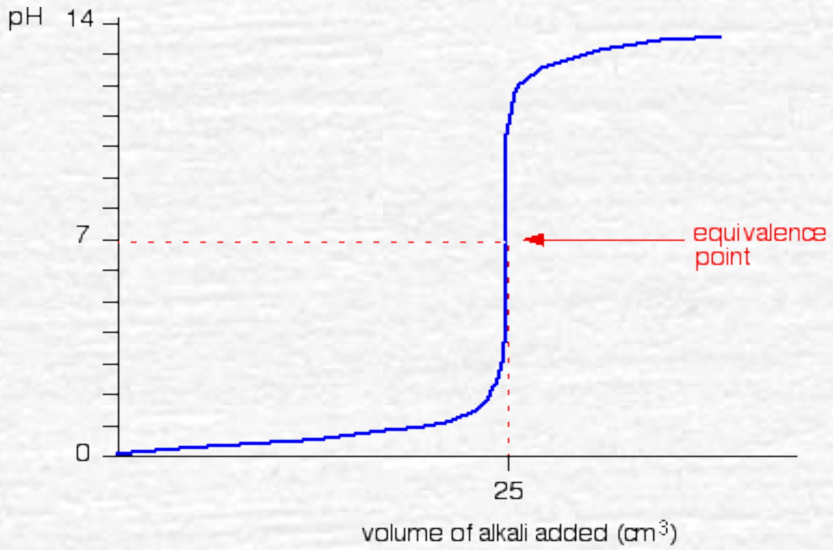
$H^+ = 3.5 \times 10^{-4}$ M

STEP 2: ESTIMATE pH: SINCE HCl IS 100% DISSOCIATED

$-\log [H^+] = -(-4 + \log 3.5) = -(-4 + 0.54) = 3.46$

For weak acids use Henderson Hasselbach Equation

Titration of Strong Acid



$$\underbrace{\mathrm{HA}}_{\text{Acid}} \rightleftharpoons \mathrm{H^+} + \underset{\text{Conjugate base}}{\mathrm{A^-}}$$

$$K_a = \frac{[\mathrm{H^+}][\mathrm{A^-}]}{[\mathrm{HA}]}$$

$$K_a = \frac{[H^+][A^-]}{[HA]}$$

(K_a is the acid dissociation constant)

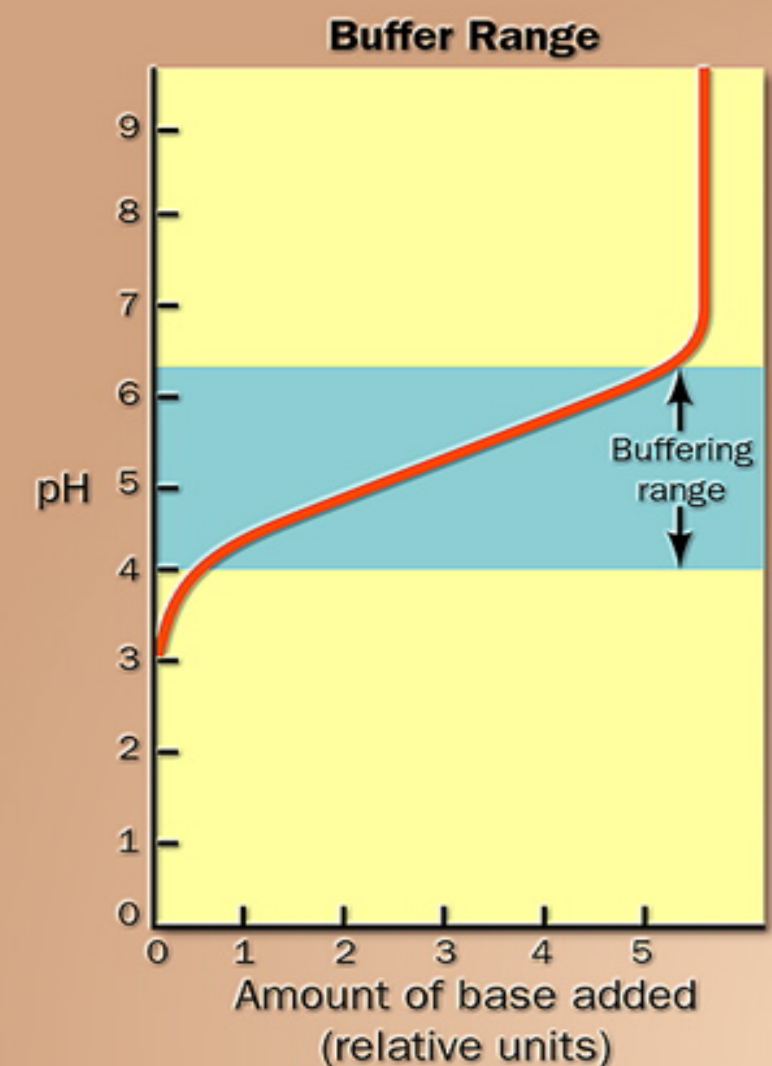
$$pK_a = -\log K_a$$

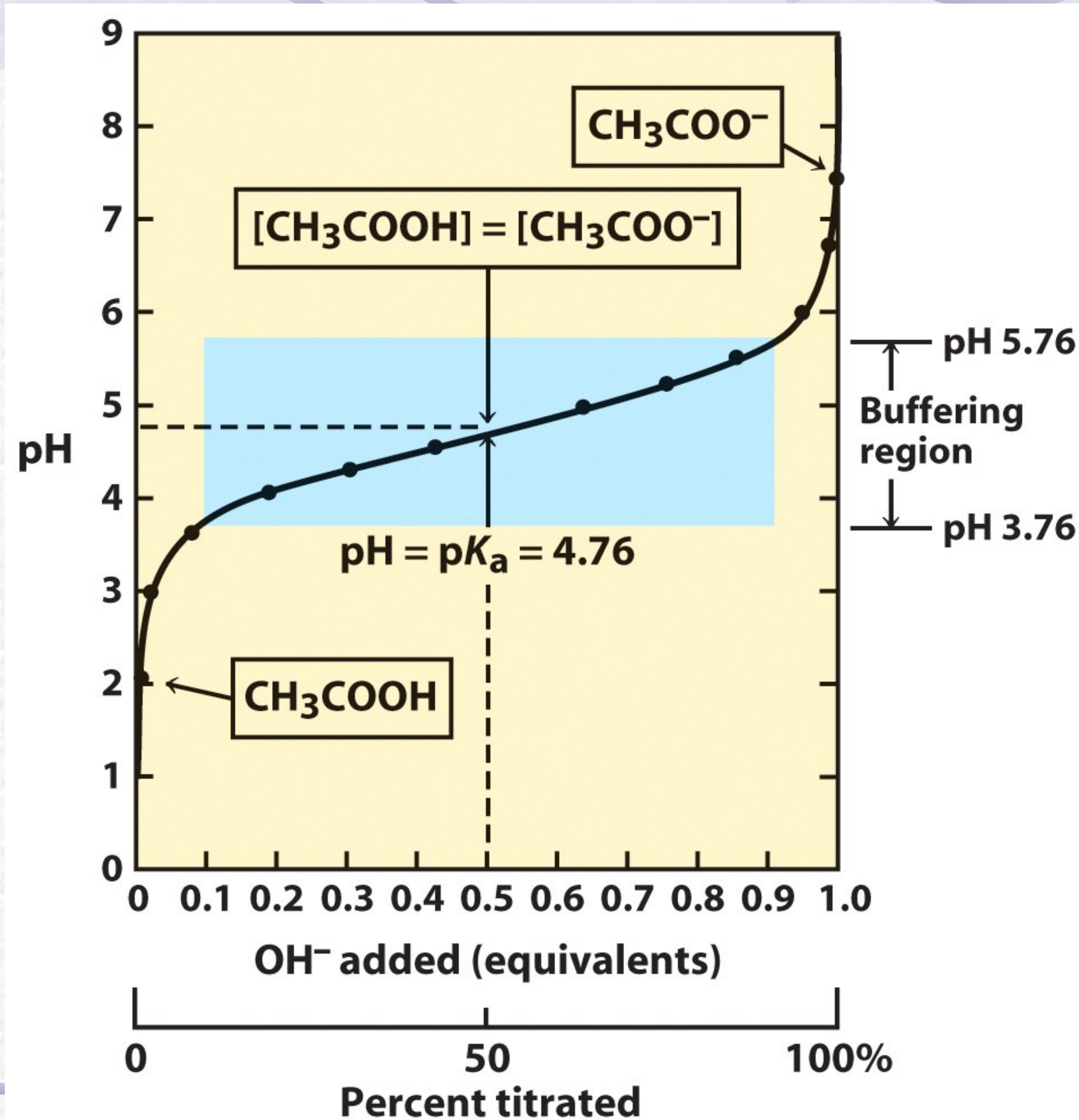
$$\mathrm{pH} = \mathrm{p}K_a + \log_{10} \frac{[\mathrm{A}^-]}{[\mathrm{HA}]}$$

HA is a weak acid

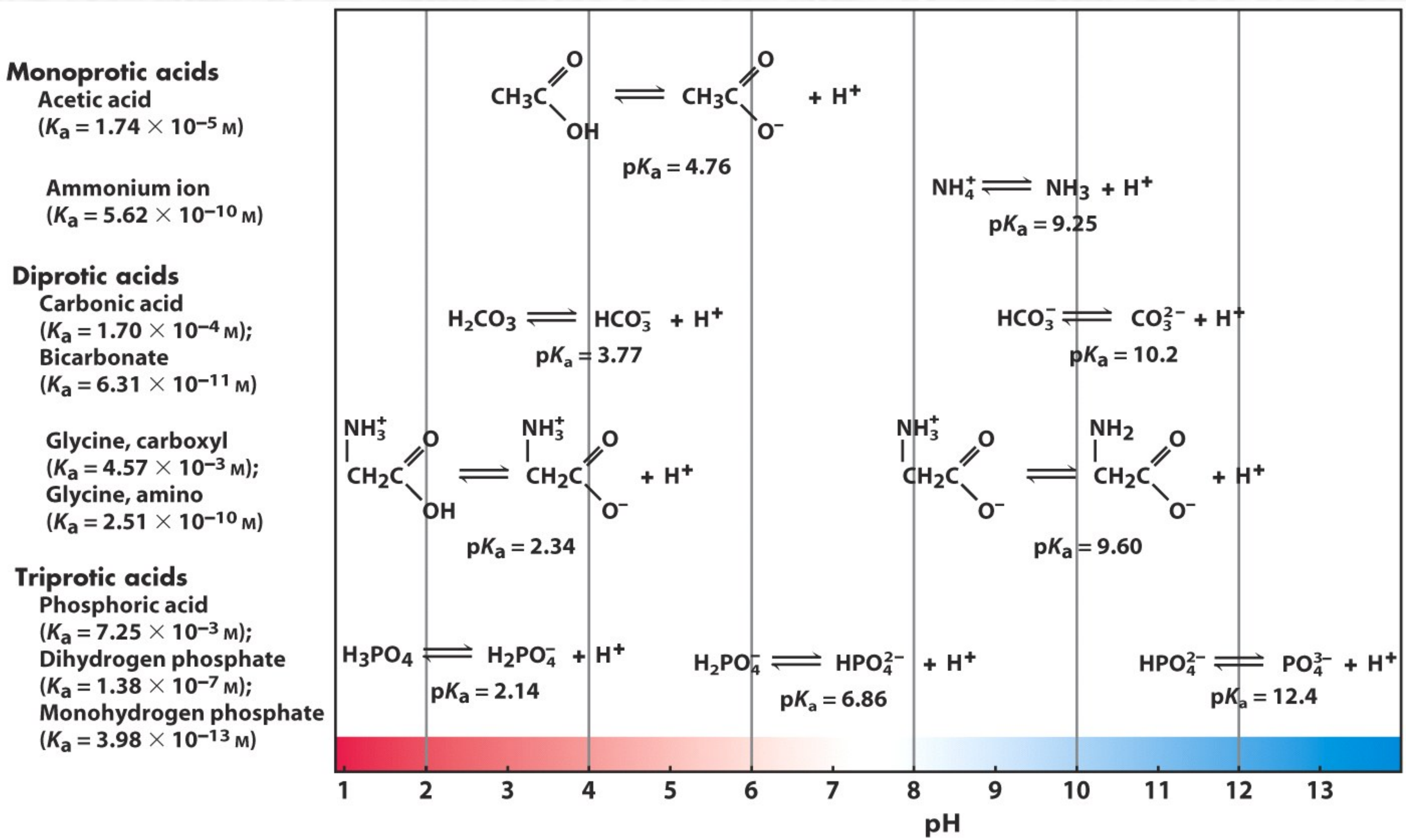
A^- is its conjugate base

[ ] refers to concentration in moles/l


Buffer Range
pH
9
8
7
6
5
4
3
2
1
0
0
1
2
3
4
5
Buffering range
Amount of base added (relative units)



pH
9
8
7
6
5
4
3
2
1
0
CH_3COO^-
$[CH_3COOH] = [CH_3COO^-]$
pH 5.76
Buffering region
pH 3.76
$pH = pK_a = 4.76$
CH_3COOH
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
OH^- added (equivalents)
0
50
100%
Percent titrated


Monoprotic acids
Acetic acid
($K_a = 1.74 \times 10^{-5}$ M)
Ammonium ion
($K_a = 5.62 \times 10^{-10}$ M)
Diprotic acids
Carbonic acid
($K_a = 1.70 \times 10^{-4}$ M);
Bicarbonate
($K_a = 6.31 \times 10^{-11}$ M)
Glycine, carboxyl
($K_a = 4.57 \times 10^{-3}$ M);
Glycine, amino
($K_a = 2.51 \times 10^{-10}$ M)
Triprotic acids
Phosphoric acid
($K_a = 7.25 \times 10^{-3}$ M);
Dihydrogen phosphate
($K_a = 1.38 \times 10^{-7}$ M);
Monohydrogen phosphate
($K_a = 3.98 \times 10^{-13}$ M)
pK_a = 4.76
$NH_4^+ \rightleftharpoons NH_3 + H^+$
pK_a = 9.25
$H_2CO_3 \rightleftharpoons HCO_3^- + H^+$
pK_a = 3.77
$HCO_3^- \rightleftharpoons CO_3^{2-} + H^+$
pK_a = 10.2
pK_a = 2.34
pK_a = 9.60
$H_3PO_4 \rightleftharpoons H_2PO_4^- + H^+$
pK_a = 2.14
$H_2PO_4^- \rightleftharpoons HPO_4^{2-} + H^+$
pK_a = 6.86
$HPO_4^{2-} \rightleftharpoons PO_4^{3-} + H^+$
pK_a = 12.4
1 2 3 4 5 6 7 8 9 10 11 12 13
pH

Dissociation of Phosphoric Acid

$$H_3PO_4$$

$$\mathrm{p}K_1 \rightleftharpoons 2.2$$

$$H_2PO_4^- + H^+$$

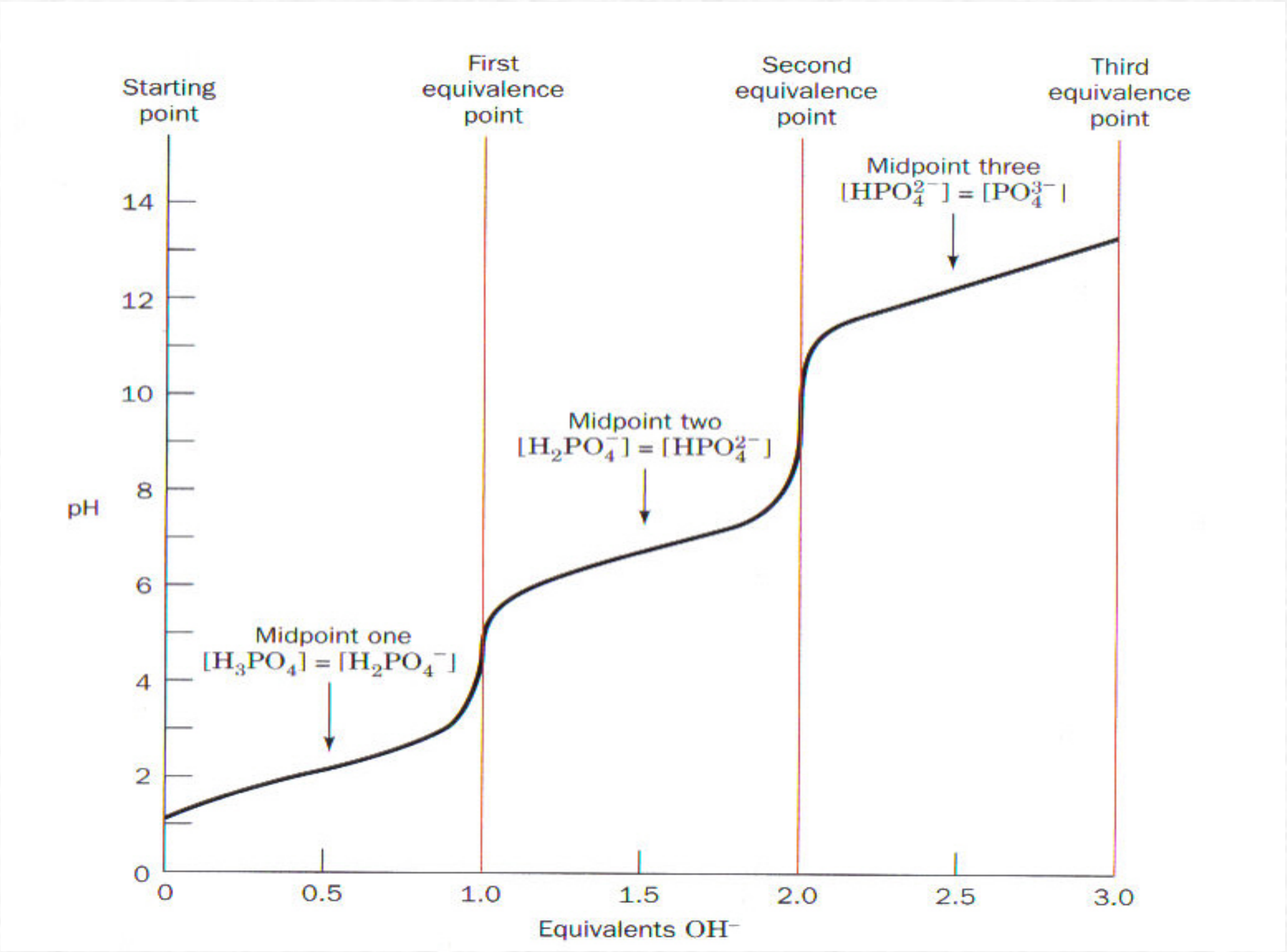
$$\mathrm{p}K_2 \rightleftharpoons 7.21$$

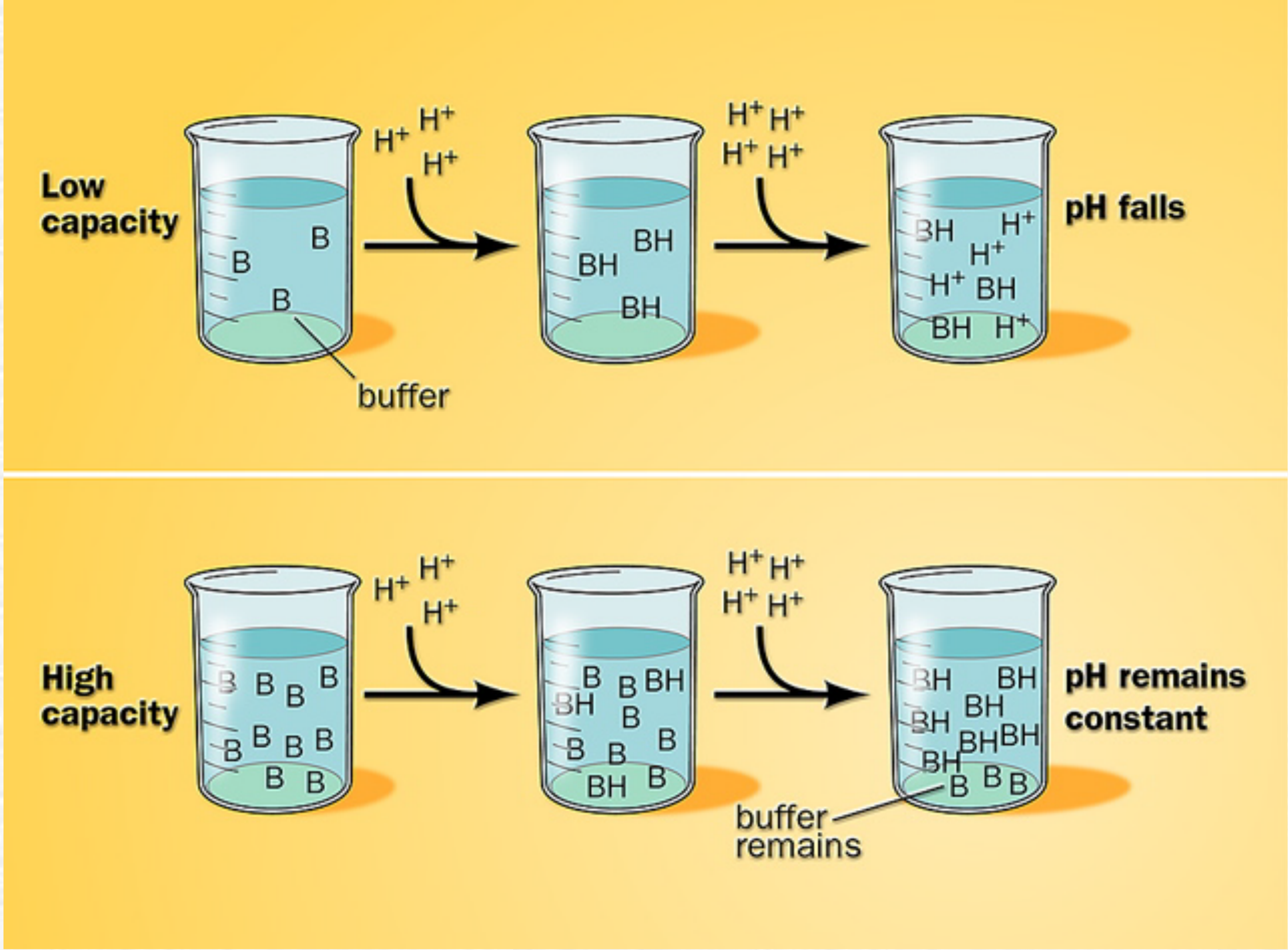
$$HPO_4^{-2} + H^+$$

$$\mathrm{p}K_3 \rightleftharpoons 12.0$$

$$PO_4^{-3} + H^+$$

Titration Curve




Low capacity
H+ H+ H+
B B B
buffer
BH BH BH
H+ H+ H+ H+
BH H+ H+ H+ BH BH H+
pH falls
High capacity
B B B B B B B B B B B
B BH BH B B B B B BH B
BH BH BH BH BH BH BH B B B
buffer remains
pH remains constant

PREPARATION OF BUFFER SOLUTIONS

EXAMPLE

Prepare 1L of 0.5M Phosphate Buffer at pH 7.5

You have available: H_3PO_4

KH_2PO_4

K_2HPO_4

K_3PO_4

Pks are 2.02, 7.21 and 12.3

STEP 1: DETERMINE WHAT ARE THE PRINCIPAL COMPONENTS OF THE SYSTEM

i.e. If pH 7.5 use pair with pK = 7.21 or $H_2PO_4^-$, HPO_4^{-2}

$$H_2PO_4^{-1} \rightleftharpoons HPO_4^{-2} + H^+ \quad pK = 7.21$$

STEP 2: USE HH EQUATION TO CALCULATE ACID:BASE

$$pH = pK_a + \mathrm{LOG}\,\frac{[HPO_4^{-2}]}{[H_2PO_4^{-}]}$$

$$\mathrm{LOG}\,\frac{[HPO_4^{-2}]}{[H_2PO_4^{-}]} = 7.5 - 7.21 = 0.29$$

$$\text{So}\ \frac{[HPO_4^{-2}]}{[H_2PO_4^{-}]} = 1.95$$

Ratio is 1.95 parts of $[HPO_4^{-2}]$ to 1 part $[H_2PO_4^{-}]$

Total parts are 1.95 + 1.0 = 2.95

% HPO_4^{-2} = [1.95/2.95] x 100 = 66.2

% $H_2PO_4^{-}$ = [1.0/2.95] x 100 = 33.8

STEP 3: SELECT SALTS TO PROVIDE THESE IONS

HPO_4^{-2} comes from K_2HPO_4

$H_2PO_4^{-1}$ comes from KH_2PO_4

STEP 4: CALCULATE THE #GM OF EACH

Moles K_2HPO_4 = 0.662 x 0.5 Moles/L = 0.33 Moles/L

Moles KH_2PO_4 = 0.338 x 0.5 Moles/L = 0.169 Moles/L

Substitute Molecular Weights:

0.33 Moles/L x 174.2 G/Mole = 57.7 G/L K_2HPO_4

0.169 Moles/L x 136.1 G/Mole = 23.0 G/L K_2HPO_4

STEP 5: WEIGH OUT THESE AMOUNTS

Dissolve in water

Dilute to 1L and check pH

Adjust pH if necessary

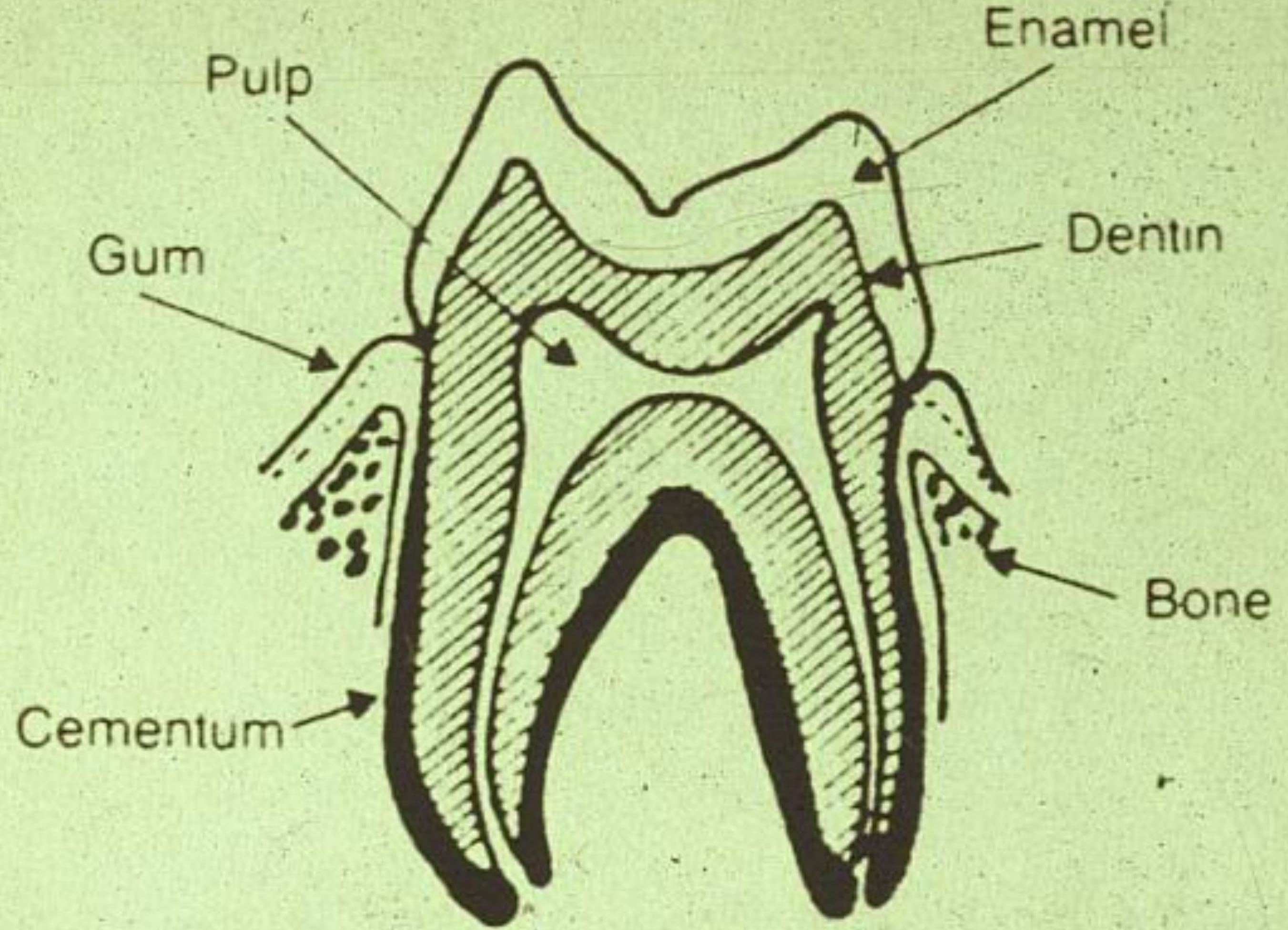
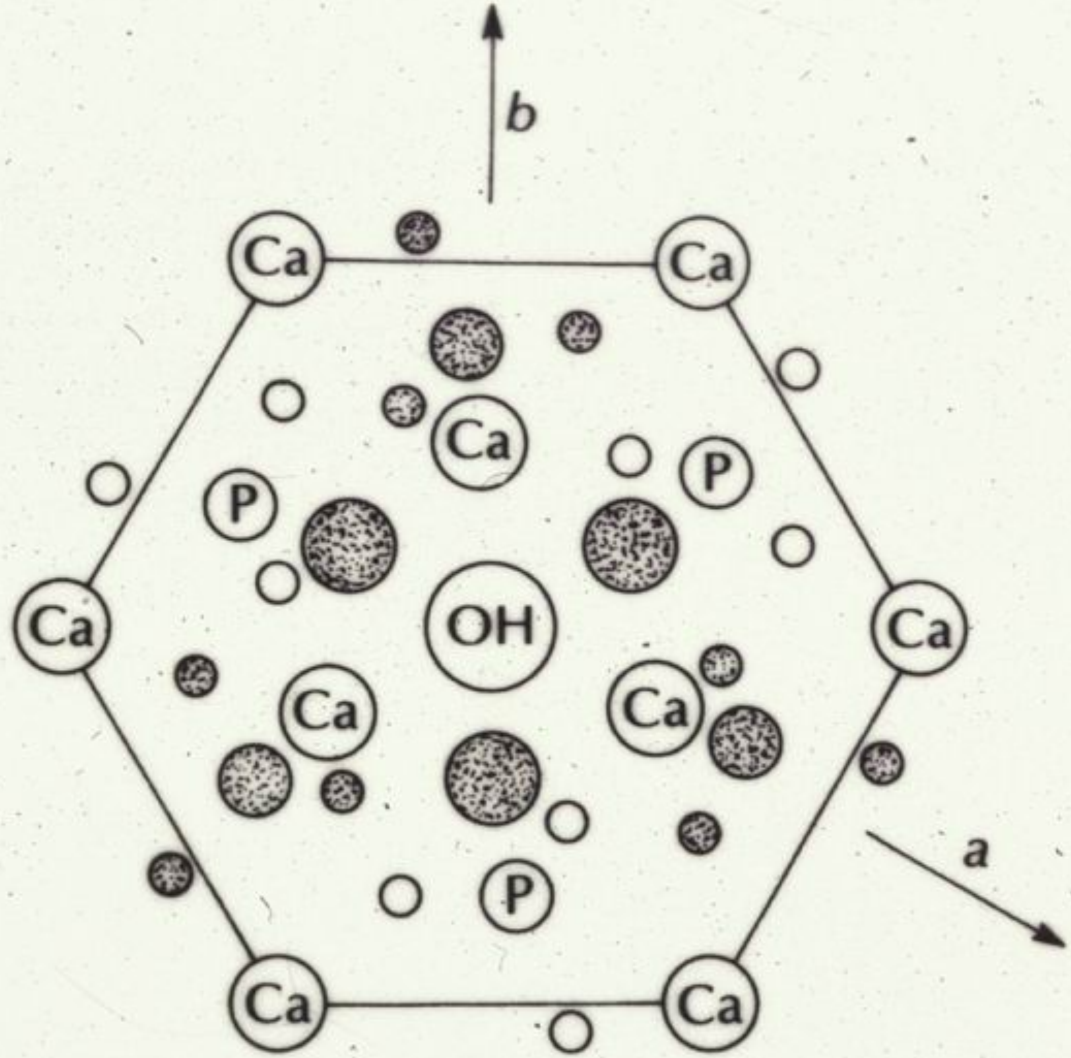


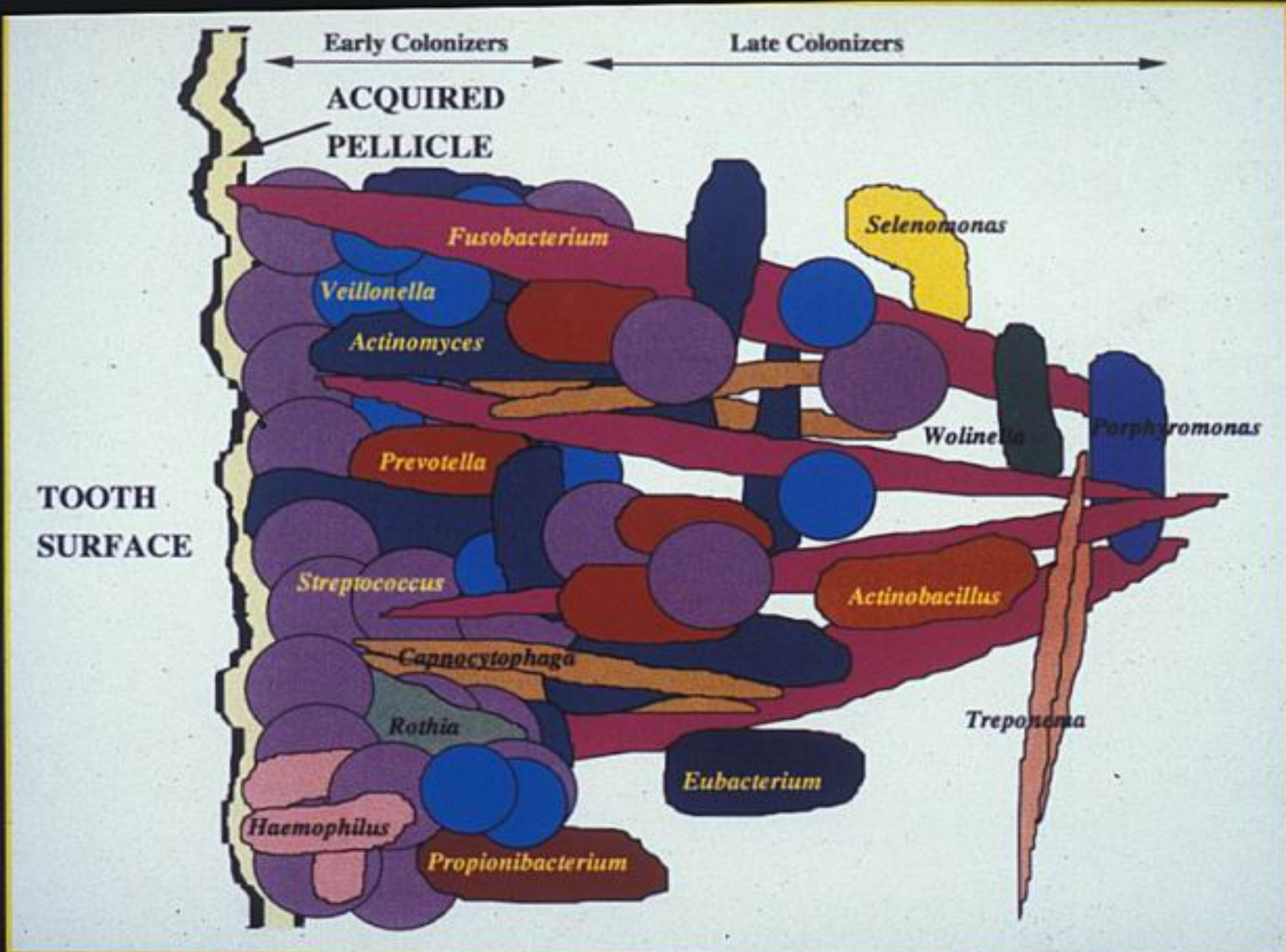
Figure 1. Schematic cross-section of a normal tooth. The gums recede with age exposing the cementum-covered dentin of the tooth root.



An end-on view of a crystallite of hydroxylapatite. The shaded atoms of Ca, P, and O represent an underlying layer. The OH^- groups form a longitudinal H-bonded array in the center. From J. A. Weatherell and C. Robinson in Zipkin,[c] p. 66.

EROSION OF TOOTH ENAMEL

$$Ca_{10}(PO_4)_6(OH)_2 \xrightarrow{H^+} 10\ Ca^{+2} + 6\ PO_4^{-3} + 2\ OH^{-1}$$



ADHERENCE AMONG PLAQUE BACTERIA

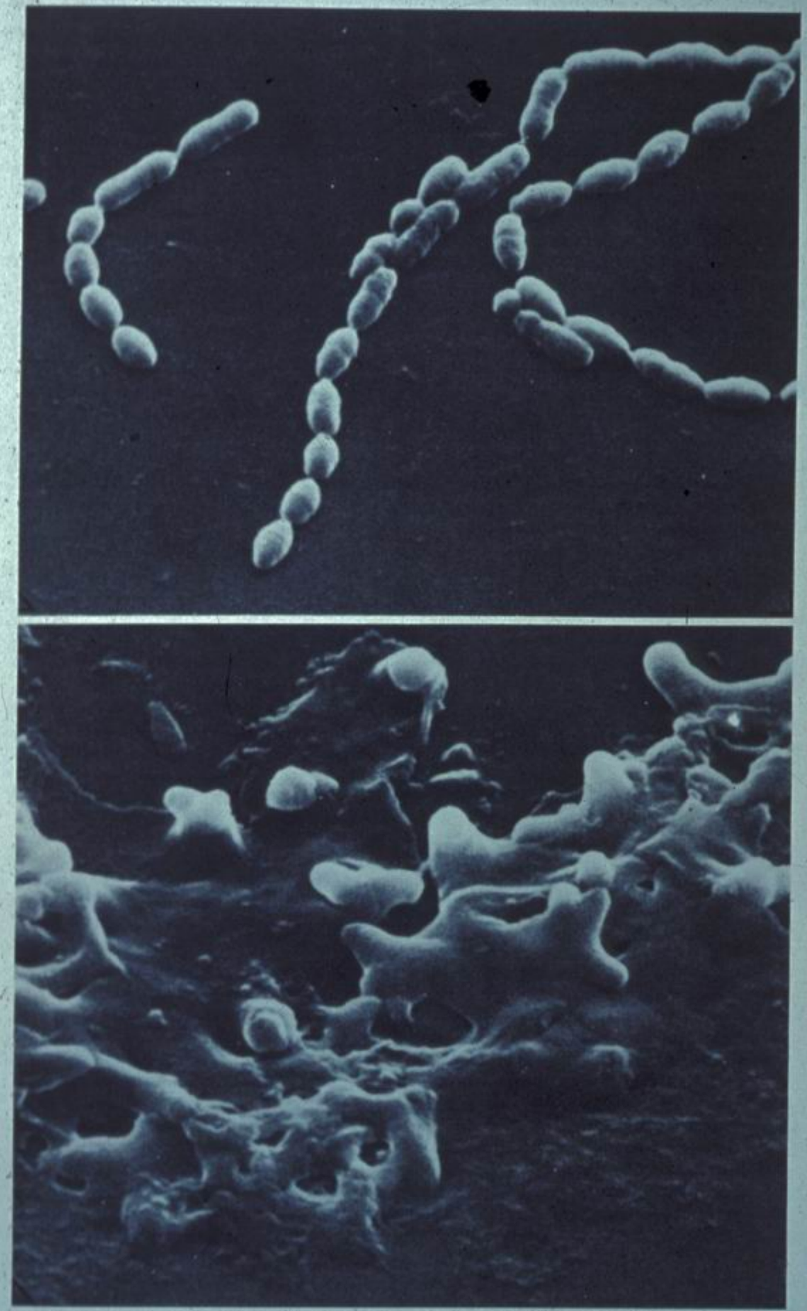


Fig. 5. *Scanning electron micrograph of S. mutans strain OMZ176 (serotype d) grown in glucose broth (top) and sucrose broth (bottom). Cells grown in the presence of sucrose were covered with amorphous capsule-like material of heavy thickness which was adherent to a glass surface. (Reproduced with permission, reference 224.)*

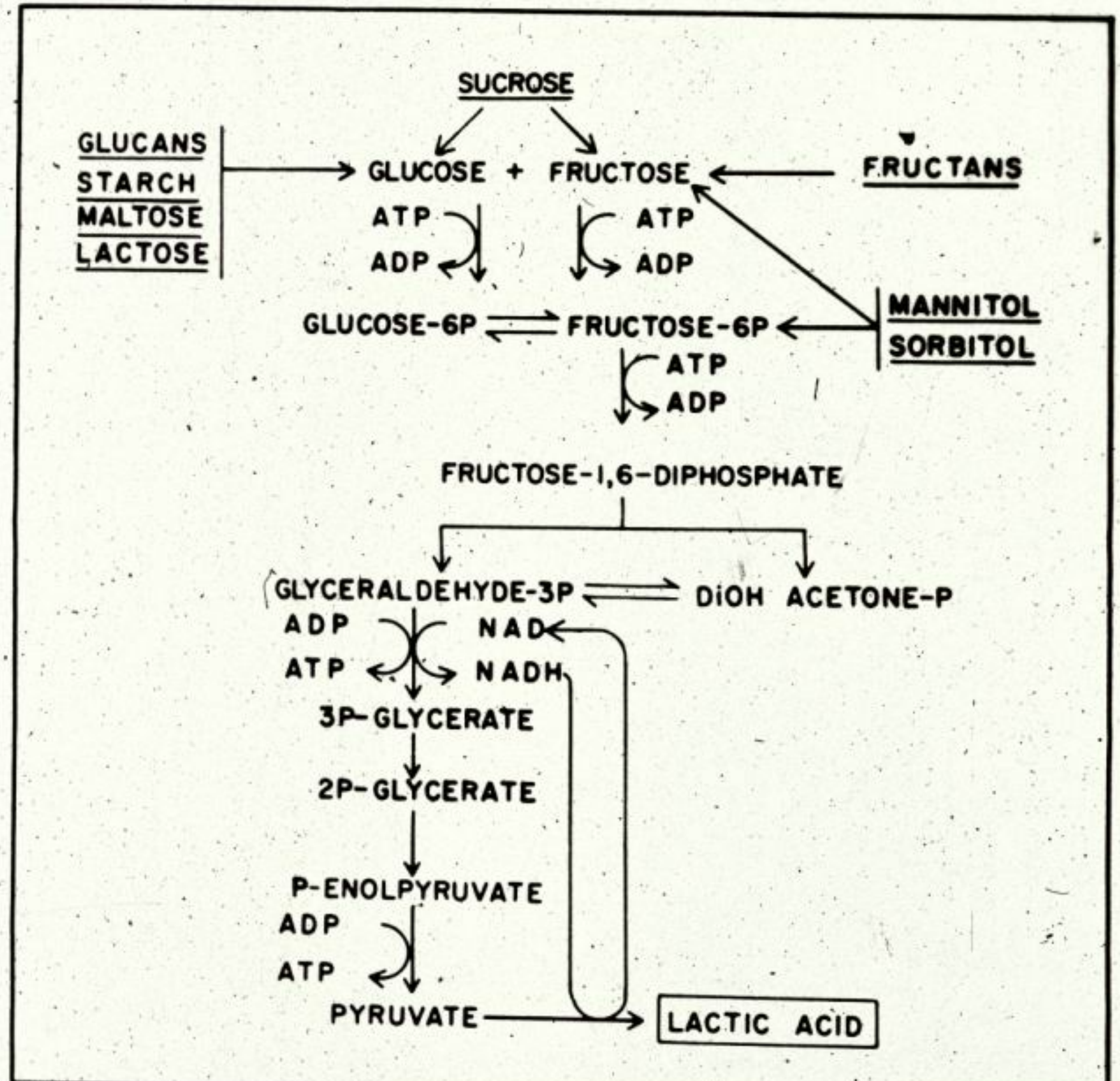


Figure 2. Relationship of carbohydrate metabolism by oral microorganisms to glycolysis.

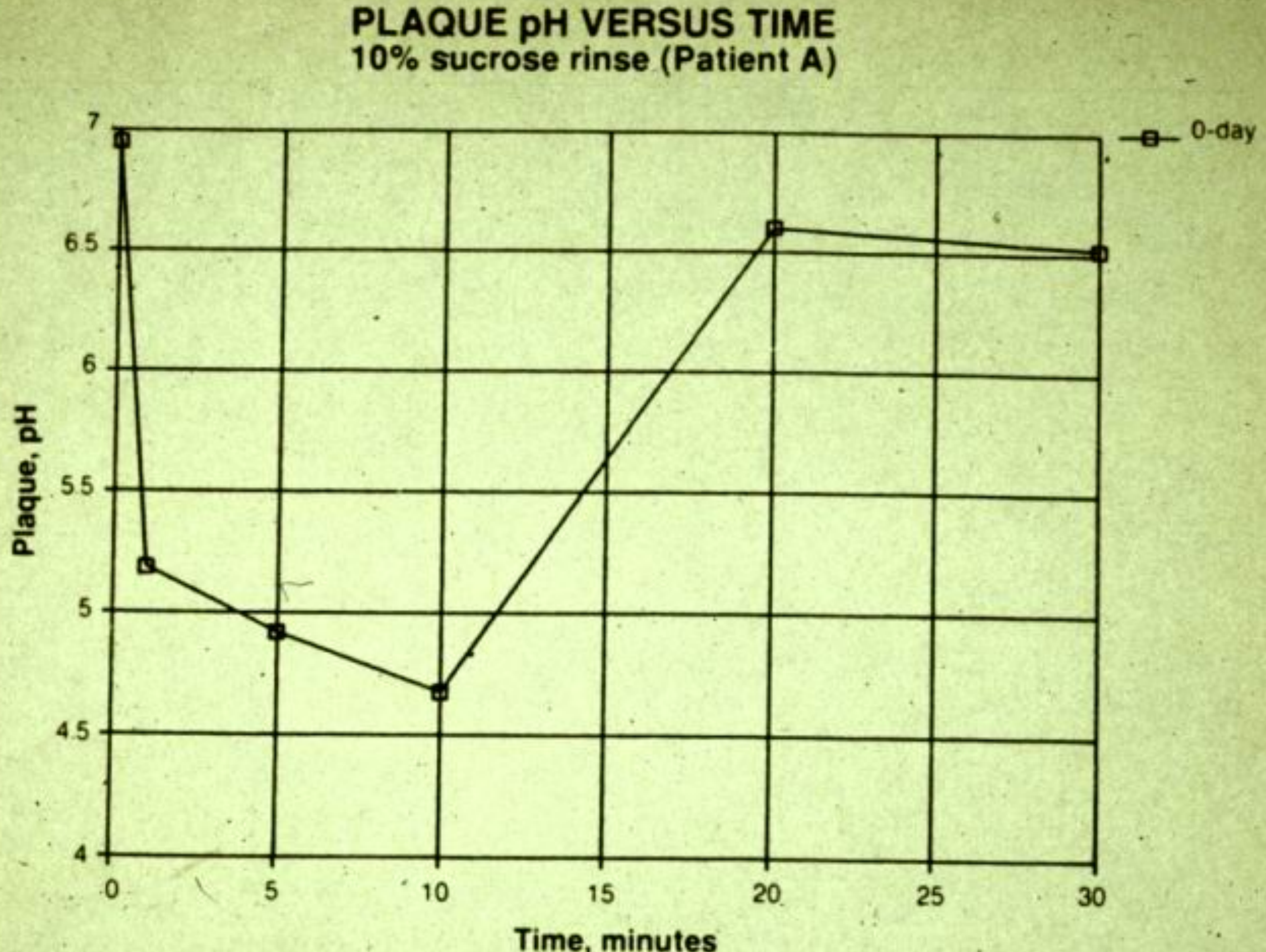


Figure 4. Typical pH curve in dental plaque on a tooth surface. This subject rinsed with a 10% sucrose solution at the start of the experiment. There was a rapid fall in pH in the plaque as the bacteria metabolized the sucrose. The subsequent rise in pH is a result of buffering by salivary components.

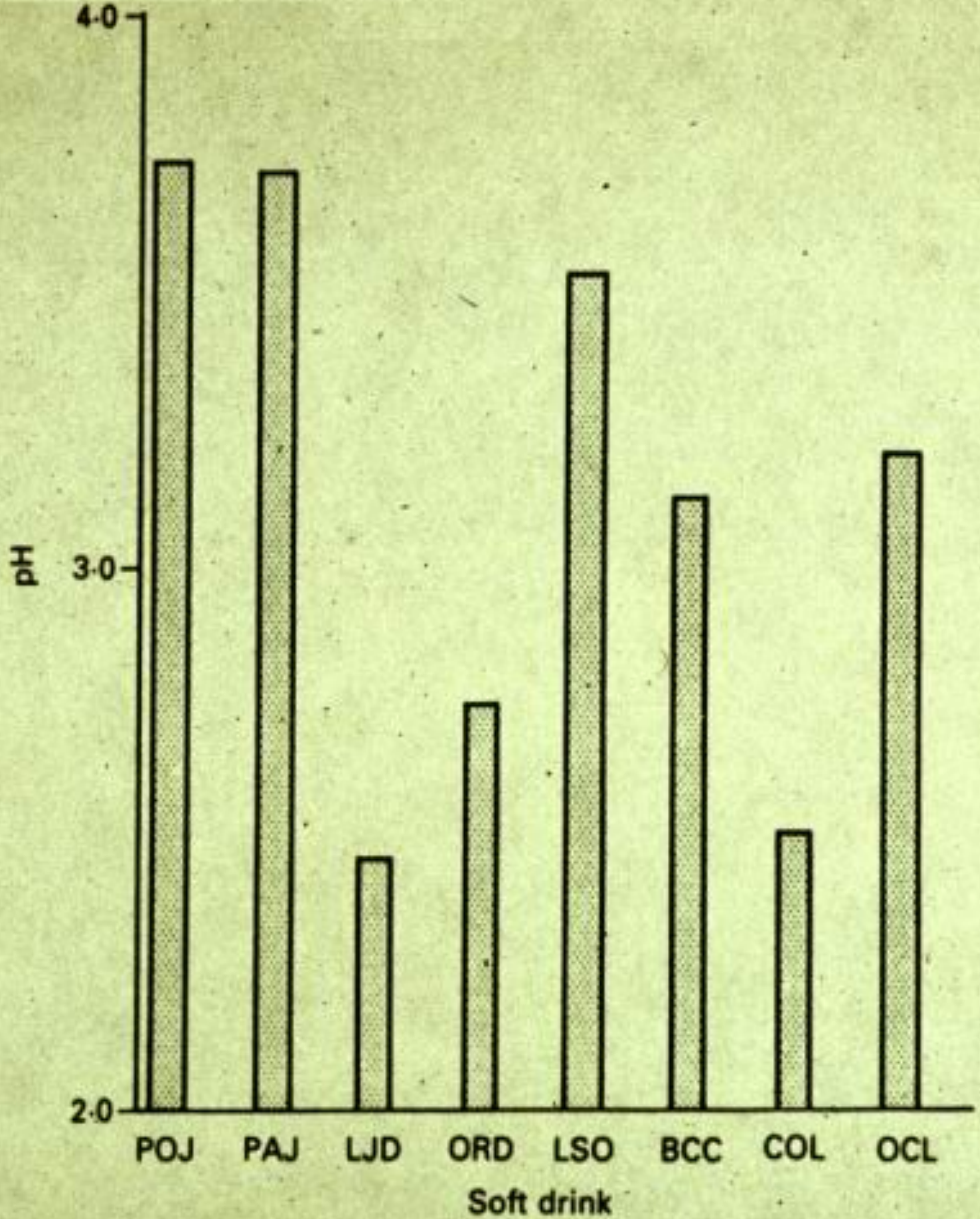


Fig. 1. pH values of eight soft drinks (in ready-to-drink form). POJ pure orange juice; PAJ, pineapple juice; LJD, 'health drink' lemon juice; ORD, orange drink; LSO, low-sugar orange drink; BCC, blackcurrant cordial; COL, carbonated cola drink; OCL, low-calorie carbonated lemonade.

Local soft drink consumption surpassed only by U.S., Mexico

Caribbean Business, Thursday, September 16,1999

Global soft drink data:
1997 Top 10 per capita consumption
(annual number of eight-ounce servings per person)

	8-oz servings	Population (in millions)	Gross National Product (per capita)
1. U.S.	861	267,900	$26,980
2. Mexico	535	97,563	3,320
3. Puerto Rico	528	3,622	8,403
4. Norway	500	4,404	31,250
5. Canada	471	30,295	19,380
6. Chile	453	14,509	4,160
7. Australia	435	18,439	18,720
8. Ireland	432	3,556	14,710
9. Belgium	419	10,204	24,710
10. Israel	405	5,535	15,920

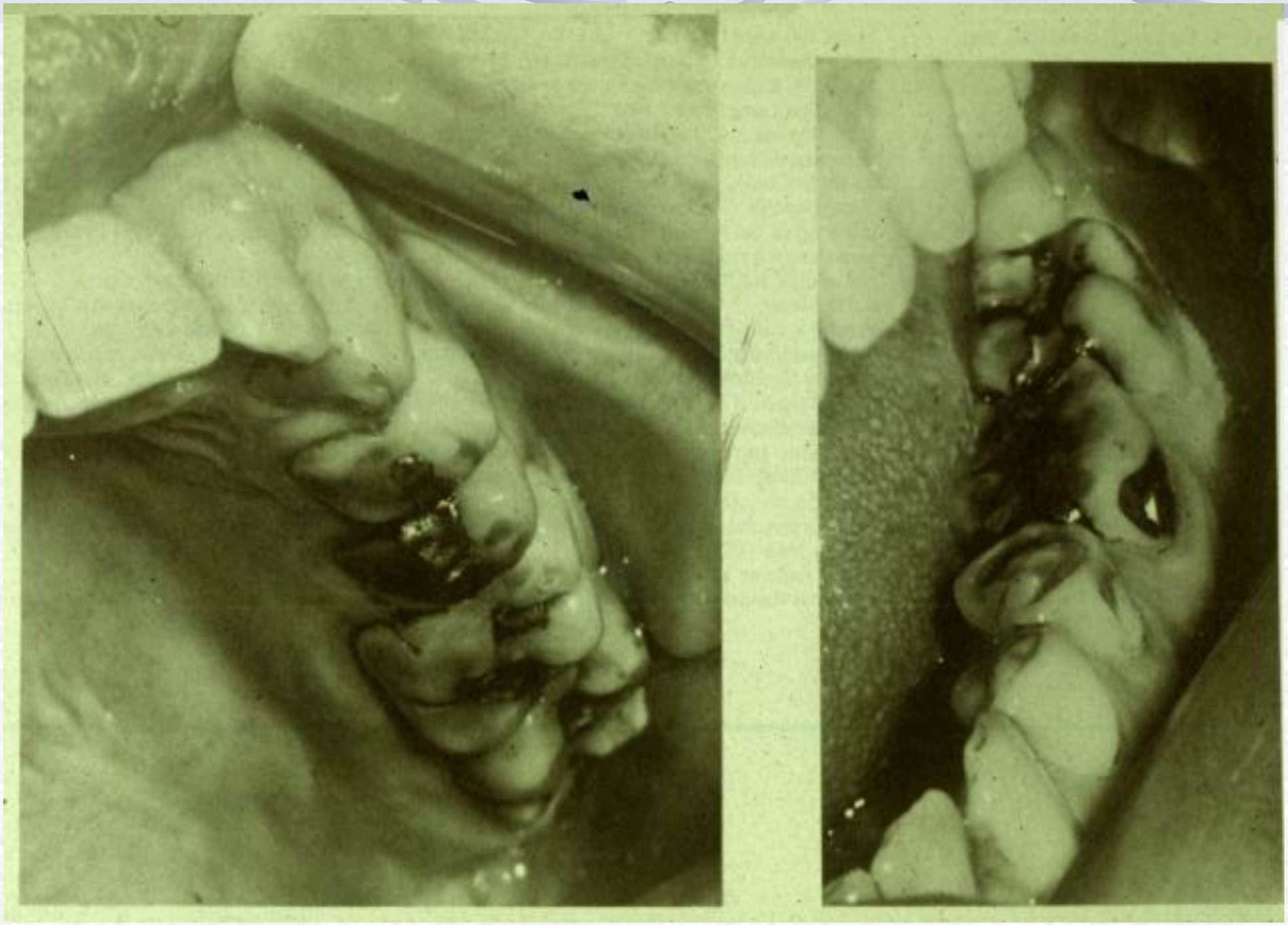


Figure 3. Rampant caries due to use of nursing bottle with sugar sweetened beverages as a pacifier.

Fig. 2
A typically located caries in AN. (Reprinted from Hellström, 1977)

Sugars and Caries

Answer the following 2 questions:

TRUE or FALSE

1. Sipping a soft drink for a longer time increases caries risk than if consumed over a shorter time period.
2. Sour candy has a greater risk for caries than sweet candy with the same sugar content.