# Foundations of Biochemistry – Dental Course

Text: Nelson & Cox-Lehninger

Principles of Biochemistry (5th ed 2008)

# Objectives

1. Recognize that cells are composed of structural and functional units:
    a. Plasma membrane
    b. Cytoplasm
    c. Cytosol
    d. Ribosomes
    e. Small metabolites
    f. Coenzymes
    g. Nucleus
    h. Genome

2. Recognize that life consists of 3 domains:
    a. Archaebacteria
    b. Eubacteria
    c. Eukaryotes

3. Distinguish between components of Eukaryotes and Prokaryotes.

4. Classify organisms according to energy and carbon acquisition:
    a. Phototrophs
    b. Chemotrophs
    c. Antotrophs
    d. Heterotrophs
        i. Lithotrophs
        ii. Organotrophs

5. Identify common bonds in biomolecules and dissociation energies Recognize the importance of sunlight as energy source for life.

6. Recognize common functional groups of biomolecules.

7. Identify molecular components in *E. coli* cell:
    a. By percentage weight.
    b. By number of different molecular species.

8. Recognize that complex molecules are often linear polymers of simple molecules.
    a. 3D structures
    b. Optical activity

[Note Sections 1.3 Physical Foundation and Section 1.4 Genetic Foundation will be covered in depth at appropriate times during the course]

9. Recognize that heritable instructions allow evolution.
    a. Mutations
    b. A biotic production of biomolecules
    c. Landmarks in the evolution of life in earth.

10. Identify organisms in which Genomes have been sequenced.

11. Recognize importance of genomic comparisons in biology and medicine.

[Form a discussion of benefits and/or risks of genomic research].

*Table* 1.2

**Biomolecular Dimensions**

The dimensions of mass* and length for biomolecules are given typically in daltons and nanometers,† respectively. One dalton (D) is the mass of one hydrogen atom, $1.67 \times 10^{-24}$ g. One nanometer (nm) is $10^{-9}$ m, or 10 Å (angstroms).

| | | Mass | |
|---|---|---|---|
| **Biomolecule** | **Length (long dimension, nm)** | **Daltons** | **Picograms** |
| Water | 0.3 | 18 | |
| Alanine | 0.5 | 89 | |
| Glucose | 0.7 | 180 | |
| Phospholipid | 3.5 | 750 | |
| Ribonuclease (a small protein) | 4 | 12,600 | |
| Immunoglobulin G (IgG) | 14 | 150,000 | |
| Myosin (a large muscle protein) | 160 | 470,000 | |
| Ribosome (bacteria) | 18 | 2,520,000 | |
| Bacteriophage $\phi$x174 (a very small bacterial virus) | 25 | 4,700,000 | |
| Pyruvate dehydrogenase complex (a multienzyme complex) | 60 | 7,000,000 | |
| Tobacco mosaic virus (a plant virus) | 300 | 40,000,000 | $6.68 \times 10^{-5}$ |
| Mitochondrion (liver) | 1,500 | | 1.5 |
| *Escherichia coli* cell | 2,000 | | 2 |
| Chloroplast (spinach leaf) | 8,000 | | 60 |
| Liver cell | 20,000 | | 8,000 |

*Molecular mass is expressed in units of daltons (D) or kilodaltons (kD) in this book; alternatively, the dimensionless term *molecular weight*, symbolized by $M_r$ and defined as the ratio of the mass of a molecule to 1 dalton of mass, is used.

†Prefixes used for powers of 10 are

| | | | |
|---|---|---|---|
| $10^{6}$ | mega M | $10^{-3}$ | milli m |
| $10^{3}$ | kilo k | $10^{-6}$ | micro $\mu$ |
| $10^{-1}$ | deci d | $10^{-9}$ | nano n |
| $10^{-2}$ | centi c | $10^{-12}$ | pico p |
| | | $10^{-15}$ | femto f |

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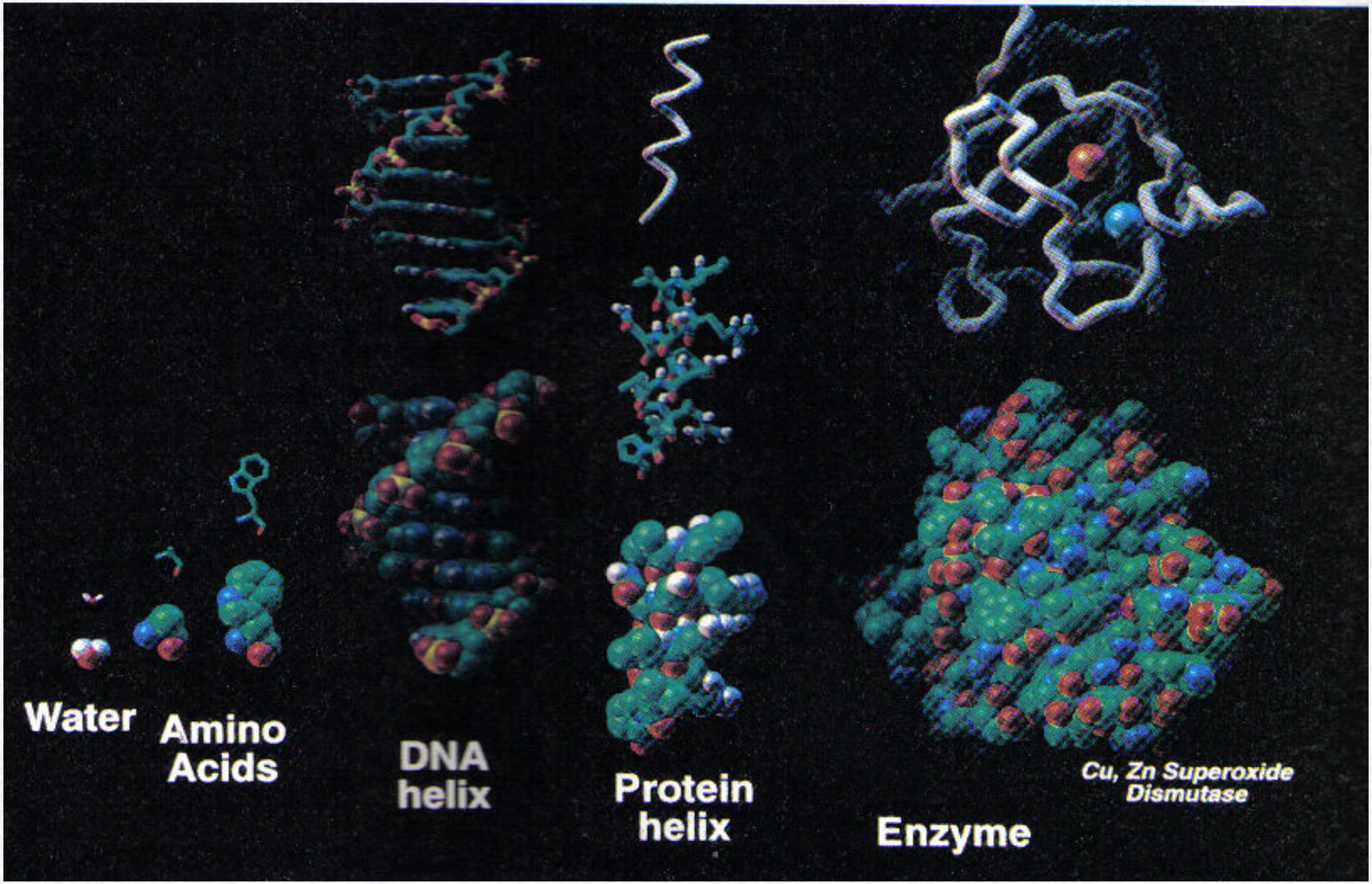
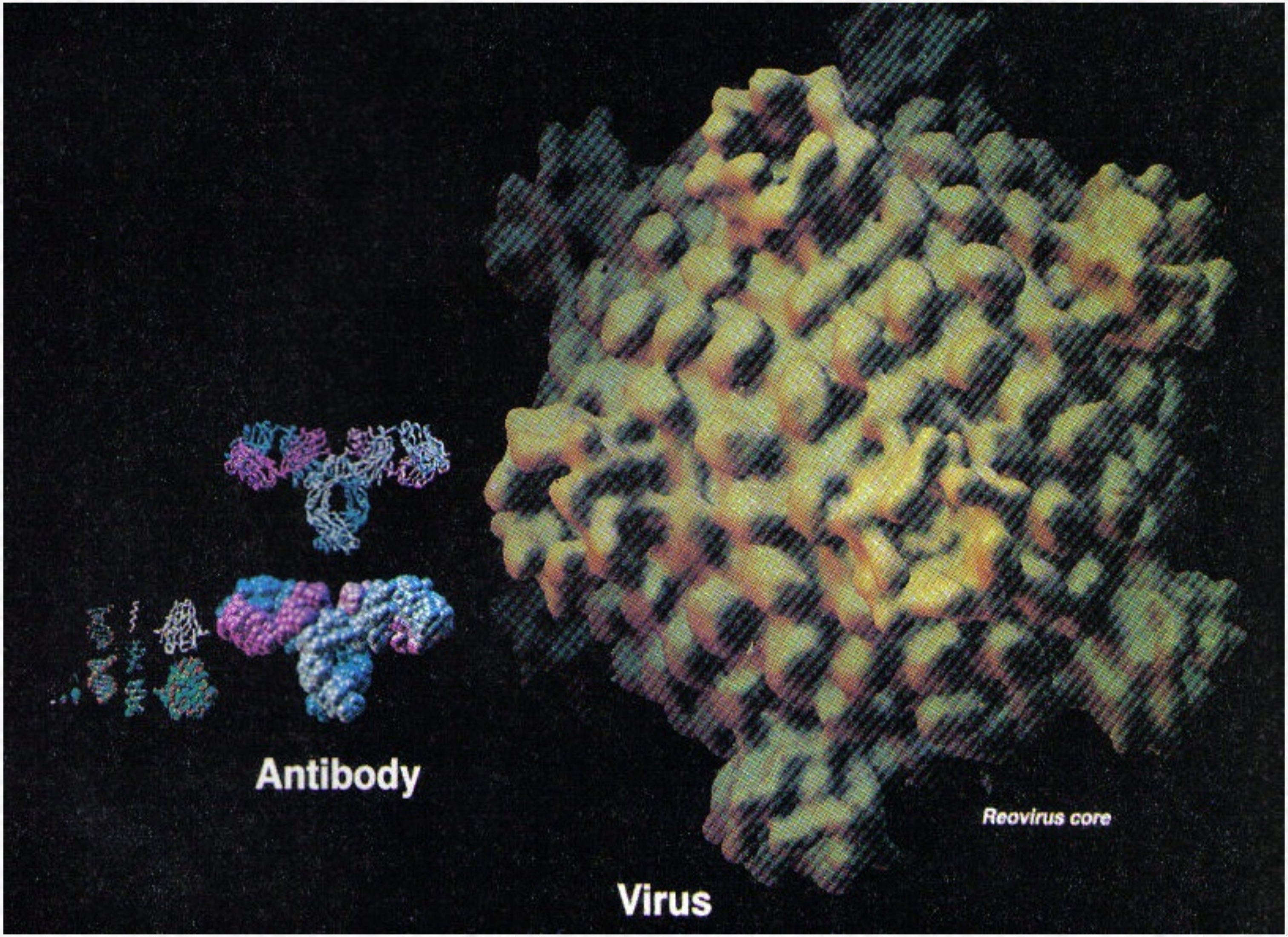
| | | | $10^{-15}$ | femto | f |

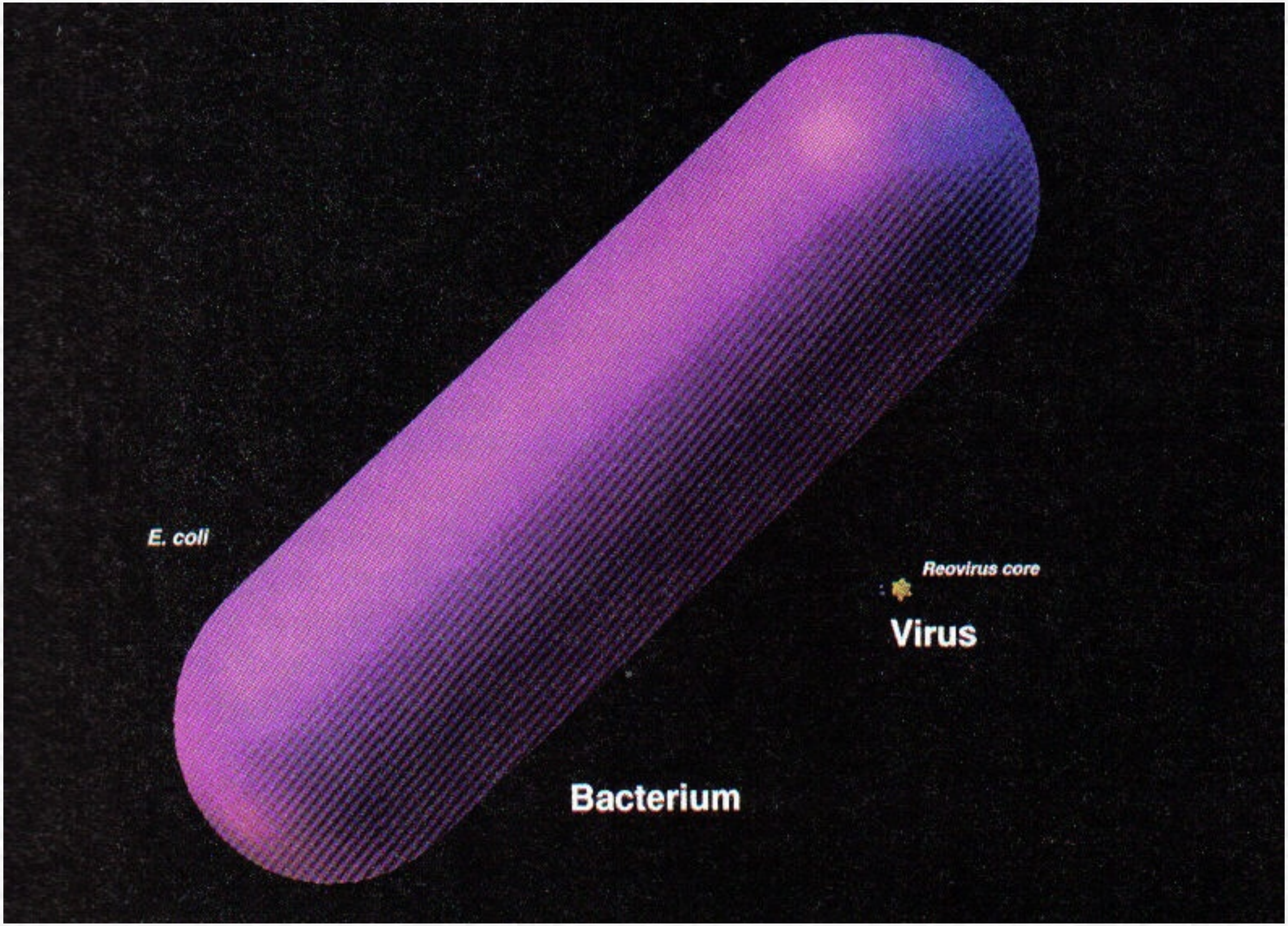
**Å Angstrom = 10** $^{-8}$cm

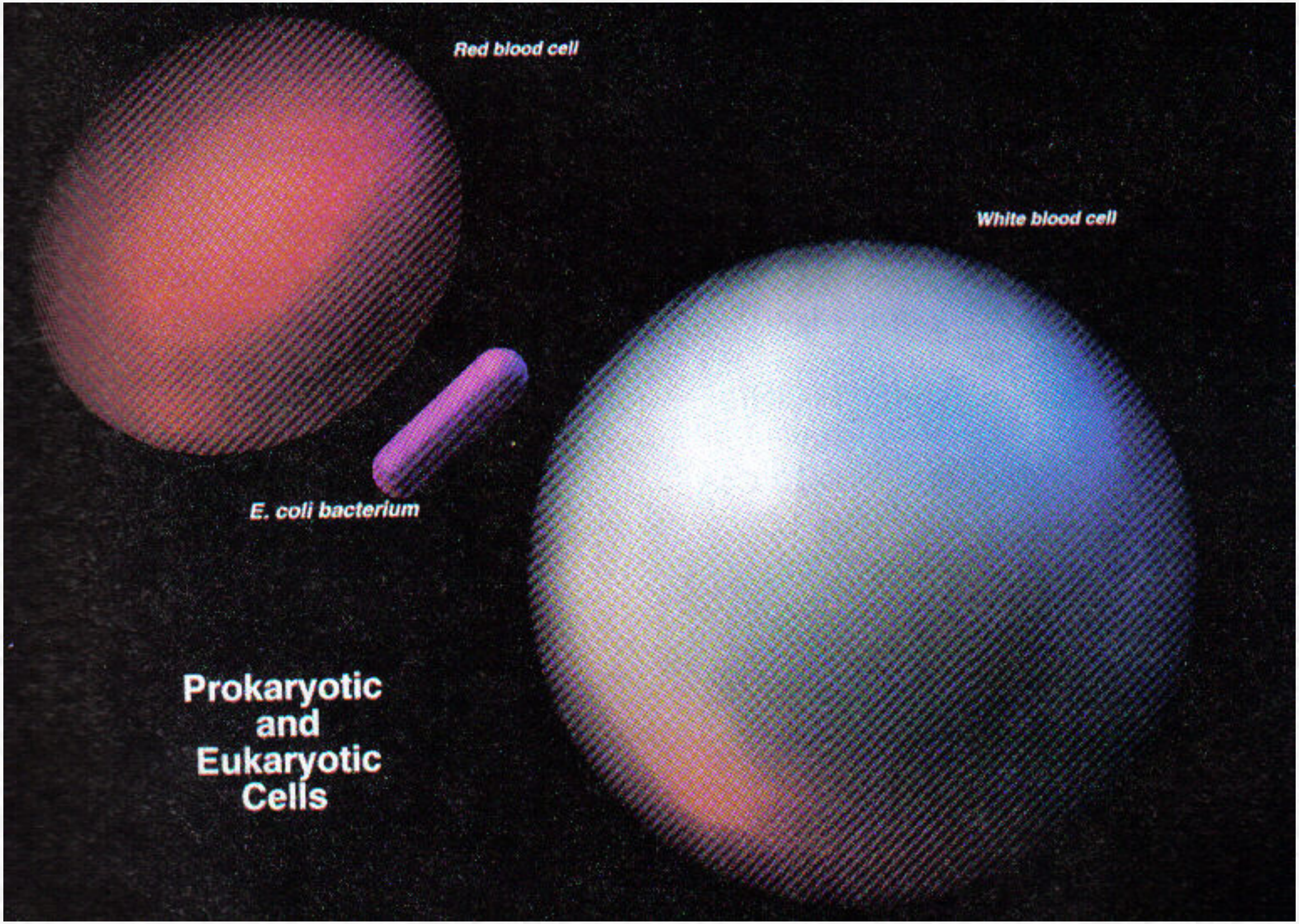
**Part per million (ppm) = 1mg/L**

# Comparative Sizes of Biomolecules, Viruses and Cells

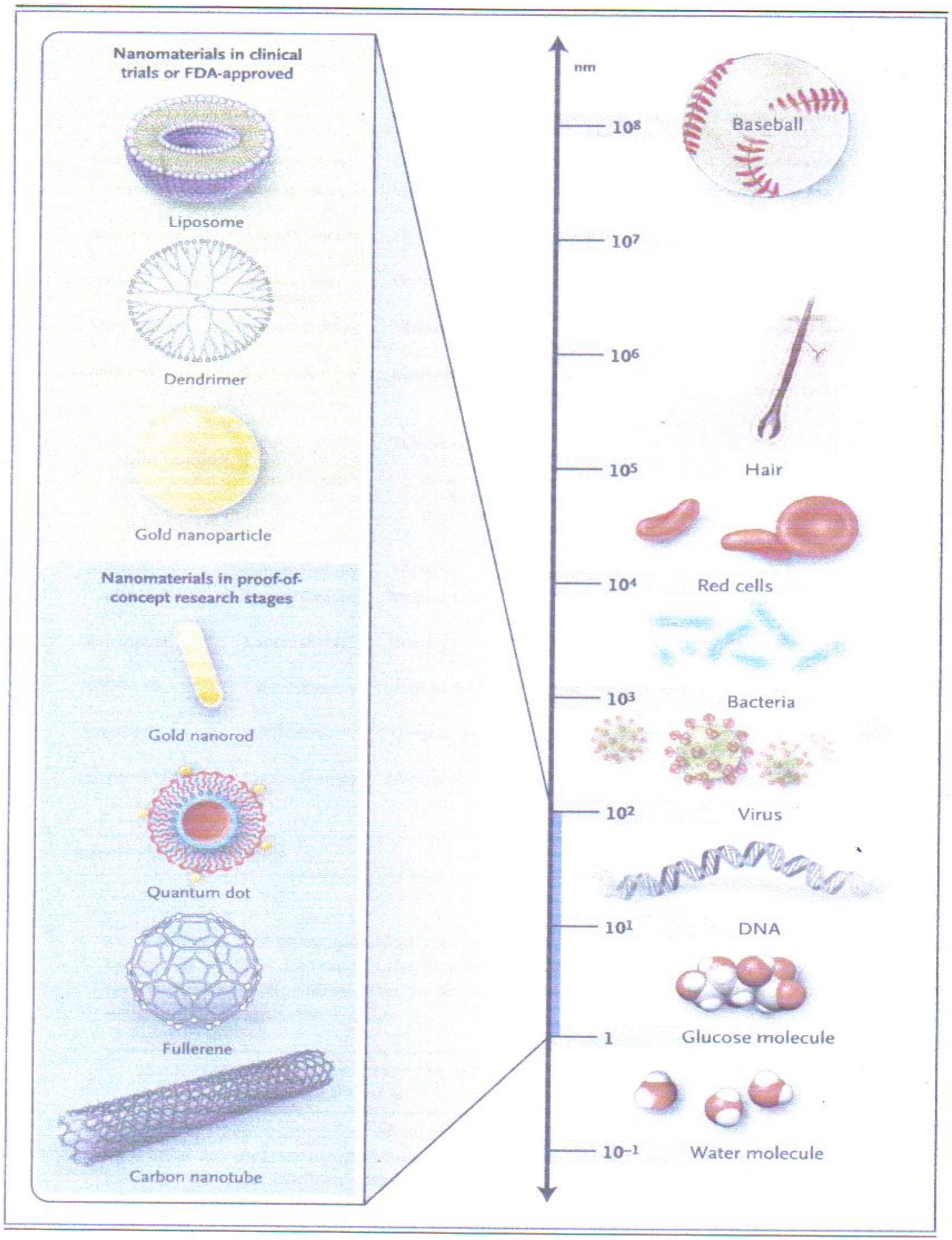



Antibody
Reovirus core
Virus


E. coli
Reovirus core
Virus
Bacterium


Red blood cell
White blood cell
E. coli bacterium
Prokaryotic and Eukaryotic Cells

Examples of nano-particles used in medicine




N. Eng J Med 363:25 (Dec 16, 2010)

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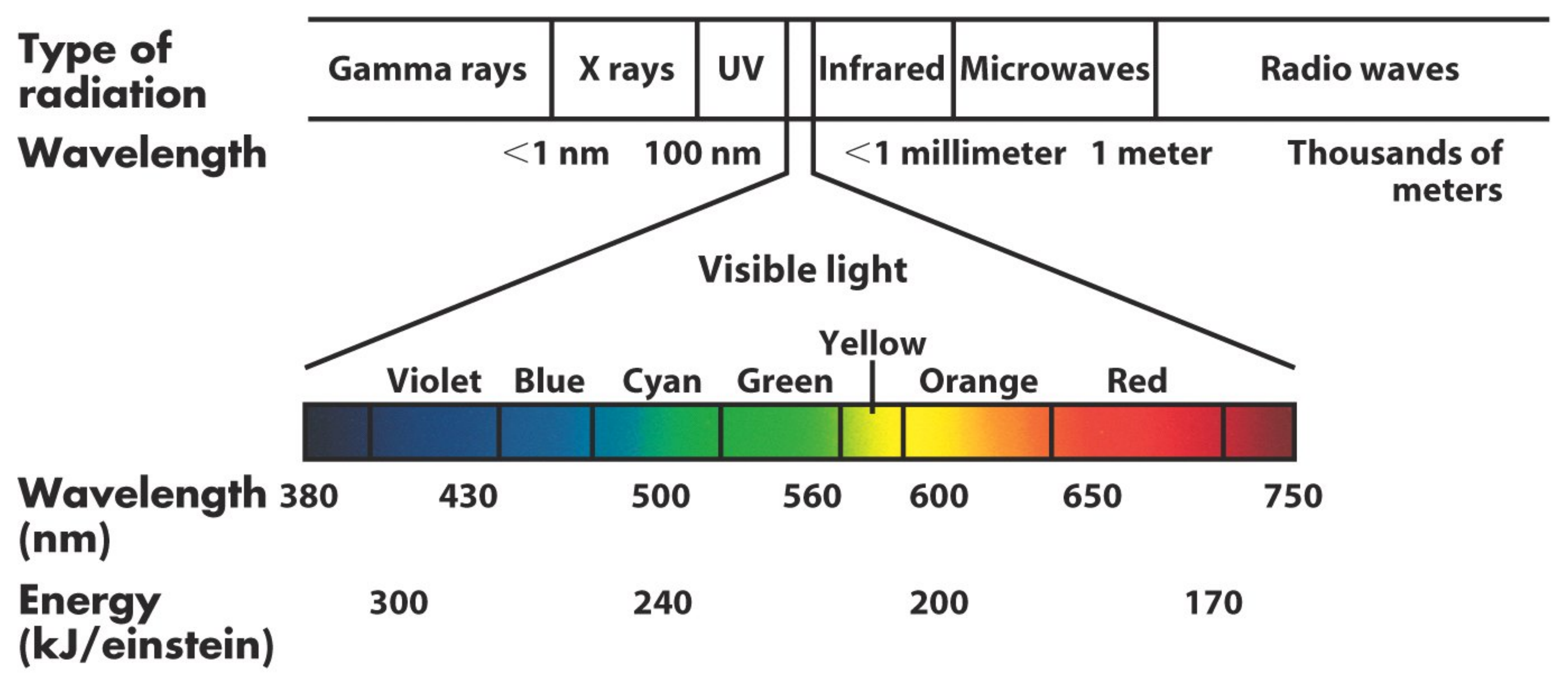
| $10^{-2}$ | centi | c | $10^{-12}$ | pico | p |
| | | | $10^{-15}$ | femto | f |

**Electron microscope resolution = 0.05nm or 0.5A**

# What is the Fundamental Source of All Life on Earth?

# ENERGY OUTPUT FROM SUN

- 3.8 x $10^{23}$ kw-hr energy per hr
- 170,000 TW strike earth (TW=trillion watts)
- One third of enegy reflected back into space
- Current useable energy is ca 13 TW
- By 2050 ca 43 TW of energy will be needed



Type of radiation
Gamma rays
X rays
UV
Infrared
Microwaves
Radio waves
Wavelength
<1 nm
100 nm
<1 millimeter
1 meter
Thousands of meters
Visible light
Violet
Blue
Cyan
Green
Yellow
Orange
Red
Wavelength (nm)
380
430
500
560
600
650
750
Energy (kJ/einstein)
300
240
200
170

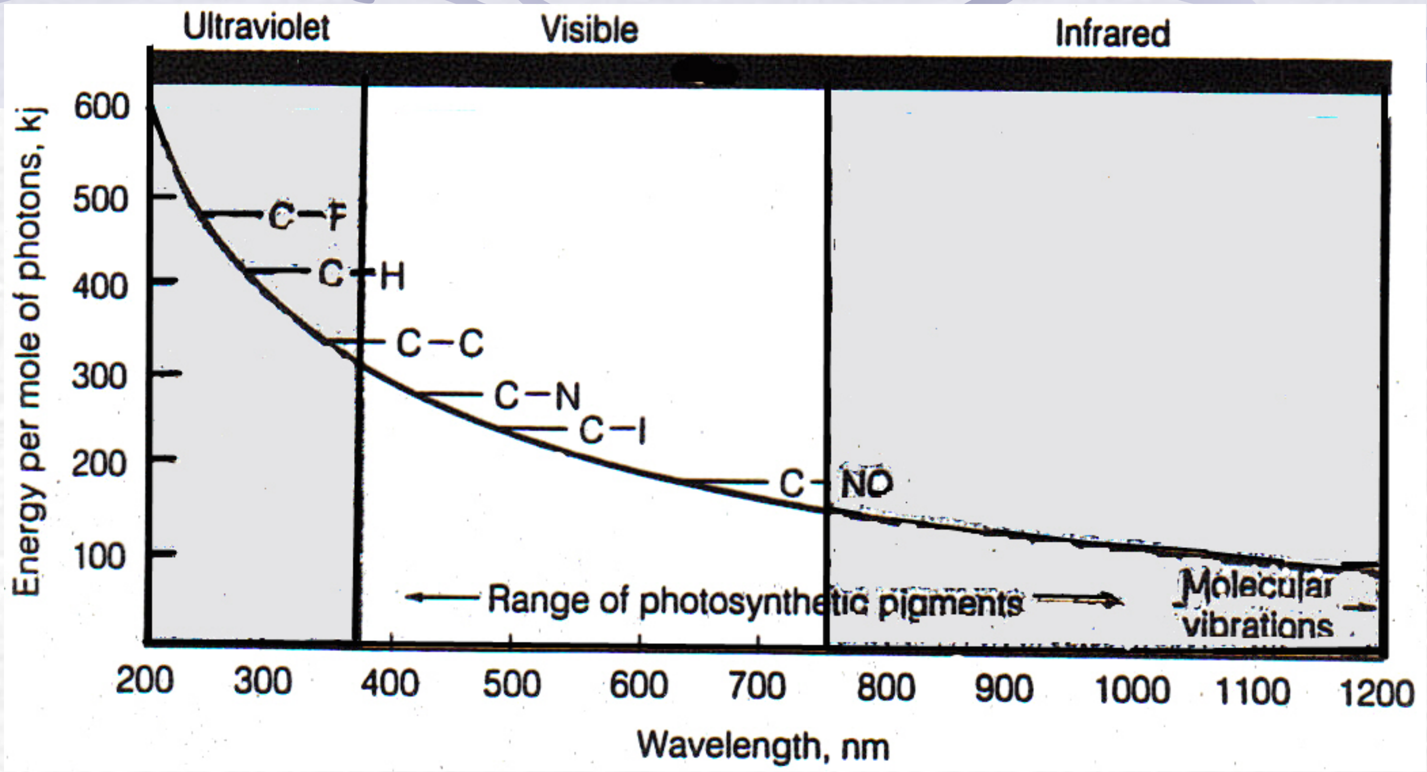
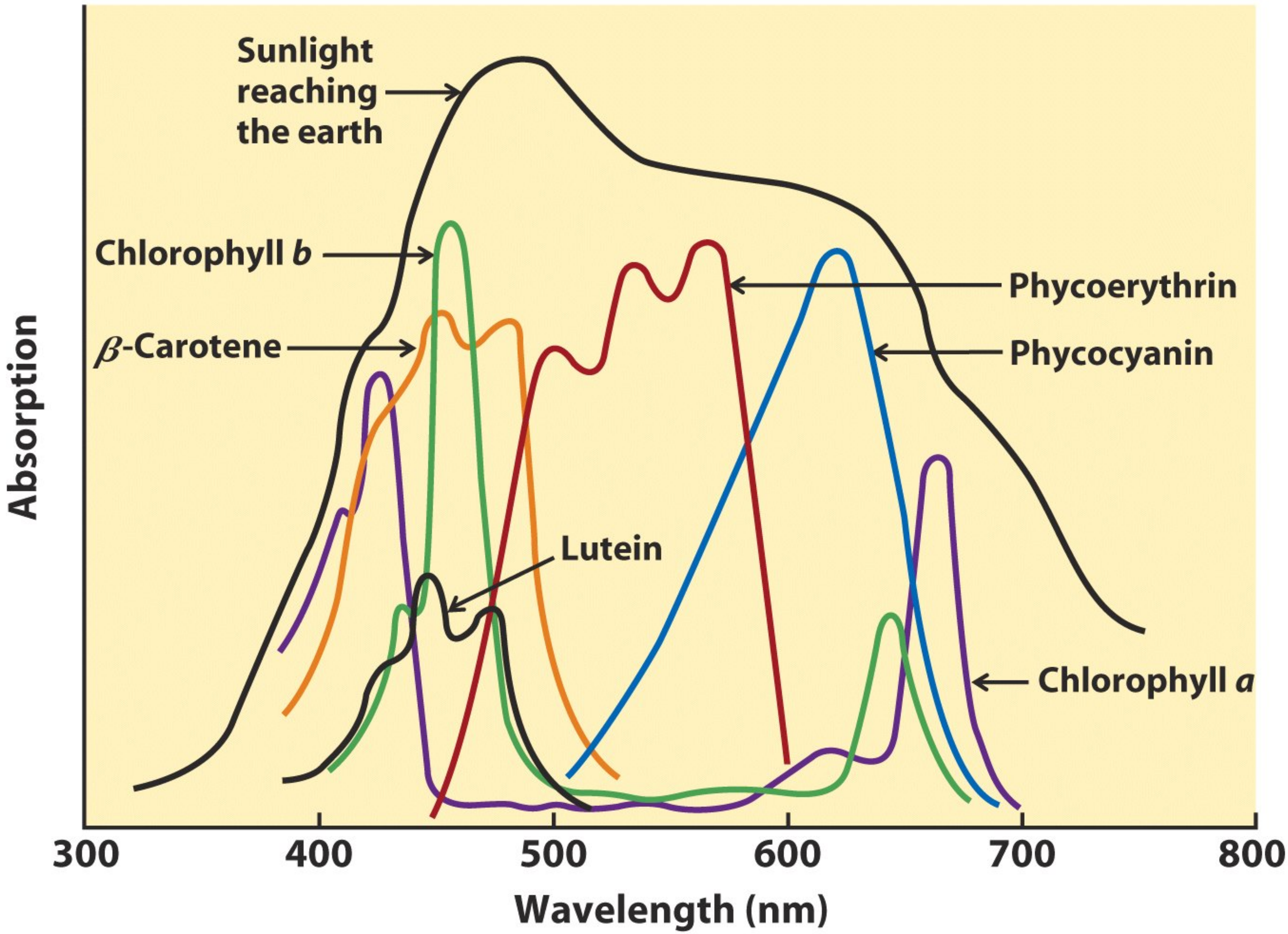



**Figure 19.6**
Energy per mole of photons (einstein) as a function of wavelength, compared with energies of several chemical bonds. Light in the UV and visible range has enough energy to directly break chemical bonds, whereas light in the long-wavelength portion of infrared region of the spectrum only causes heat-producing molecular vibrations.

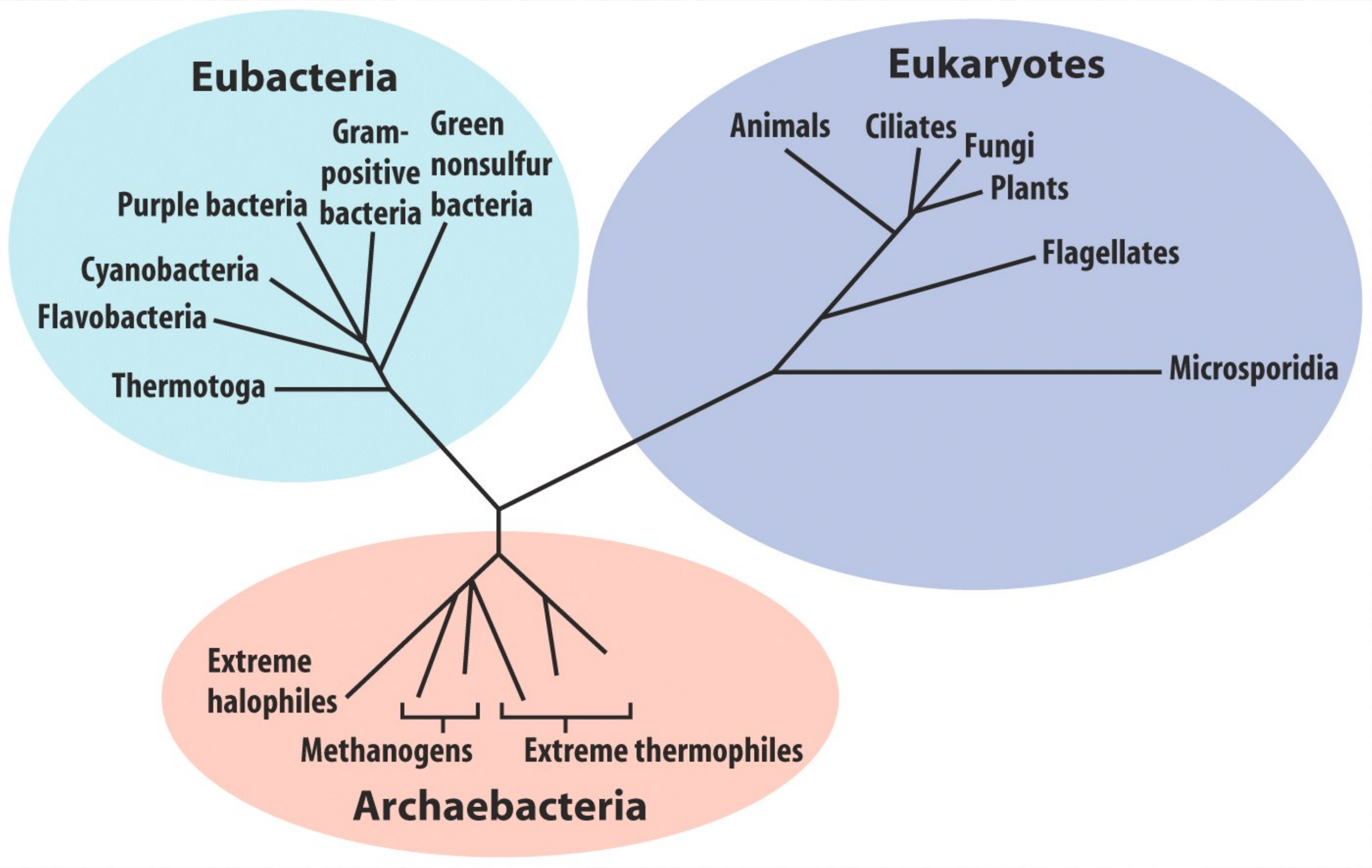


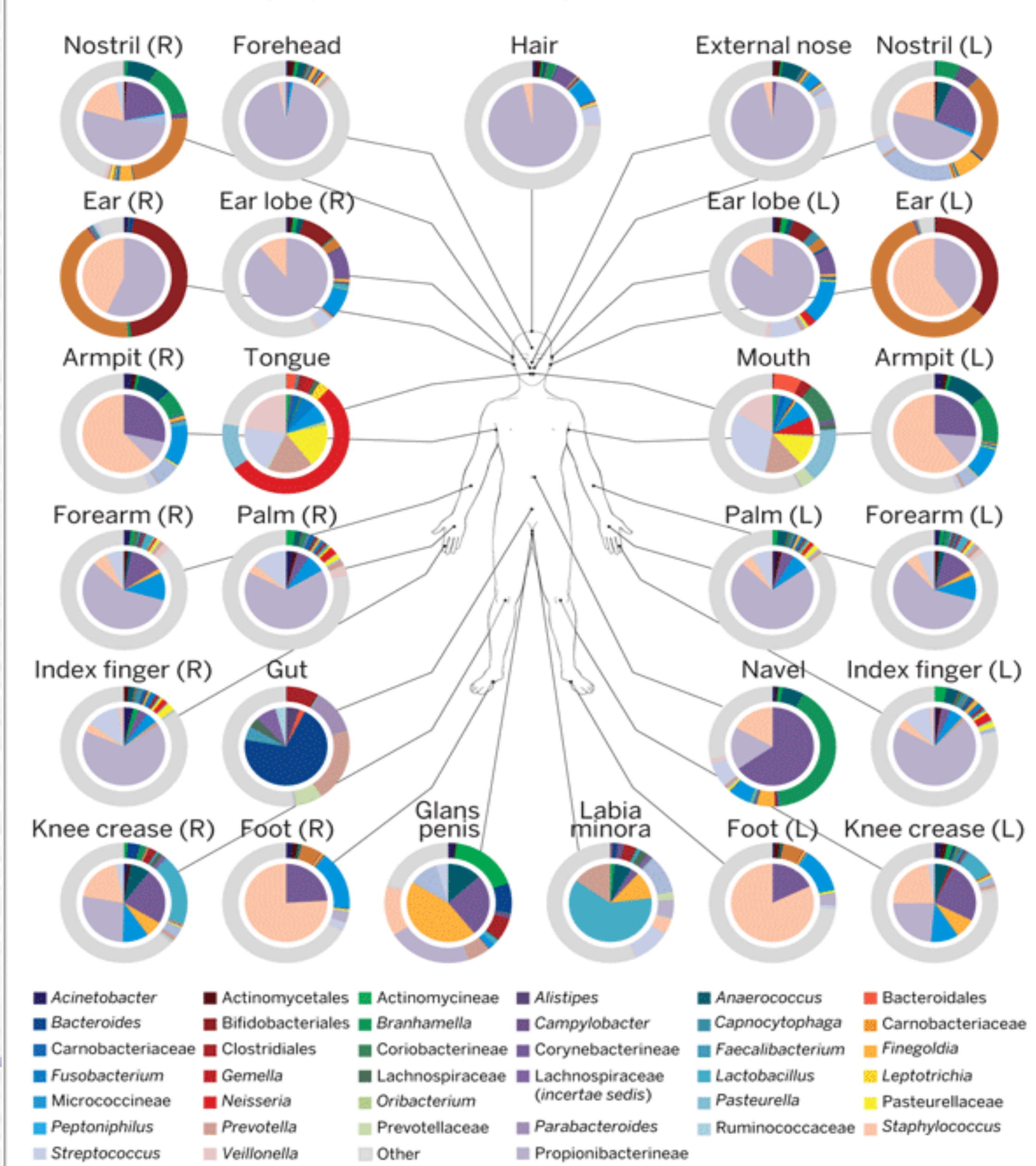
Sunlight reaching the earth
Chlorophyll *b*
β-Carotene
Phycoerythrin
Phycocyanin
Lutein
Chlorophyll *a*
Absorption
300
400
500
600
700
800
Wavelength (nm)

**TABLE 1–1** **Strengths of Bonds Common in Biomolecules**

| *Type of bond* | *Bond dissociation energy* (kJ/mol)* | *Type of bond* | *Bond dissociation energy (kJ/mol)* |
|---|---|---|---|
| **Single bonds** | | **Double bonds** | |
| O—H | 470 | C═O | 712 |
| H—H | 435 | C═N | 615 |
| P—O | 419 | C═C | 611 |
| C—H | 414 | P═O | 502 |
| N—H | 389 | | |
| C—O | 352 | **Triple bonds** | |
| C—C | 348 | C≡C | 816 |
| S—H | 339 | N≡N | 930 |
| C—N | 293 | | |
| C—S | 260 | | |
| N—O | 222 | | |
| S—S | 214 | | |

*The greater the energy required for bond dissociation (breakage), the stronger the bond.


Eubacteria
Gram-positive bacteria
Green nonsulfur bacteria
Purple bacteria
Cyanobacteria
Flavobacteria
Thermotoga
Eukaryotes
Animals
Ciliates
Fungi
Plants
Flagellates
Microsporidia
Extreme halophiles
Methanogens
Extreme thermophiles
Archaebacteria




**MAP OF MICROBIOME** In a survey of bacteria from 27 sites in nine healthy adults, researchers found that certain lineages of bacteria were common to all subjects (represented in the inner circles), whereas many more bacterial lineages were found in some people but not others (represented in the outer circles).

Microbes co-inhabiting our bodies outnumber human cells by a factor of 10. They account for 90% of all protein-encoding cells

They protects us from pathogens, synthesize essential vitamins,enzymes for digestion andcontribute to such human factors as obesity, food digestion and pill metabolism.

Imbalances of microbes can result in auto-immune diseases such as Crohn's and skin disorders like eczema and psoriasis.

In the mouth, bacteria in saliva can be different from that on the teeth.

In fact, bacteria on one tooth may be different from the tooth next to it.

## TABLE 1–3 Comparison of Prokaryotic and Eukaryotic Cells

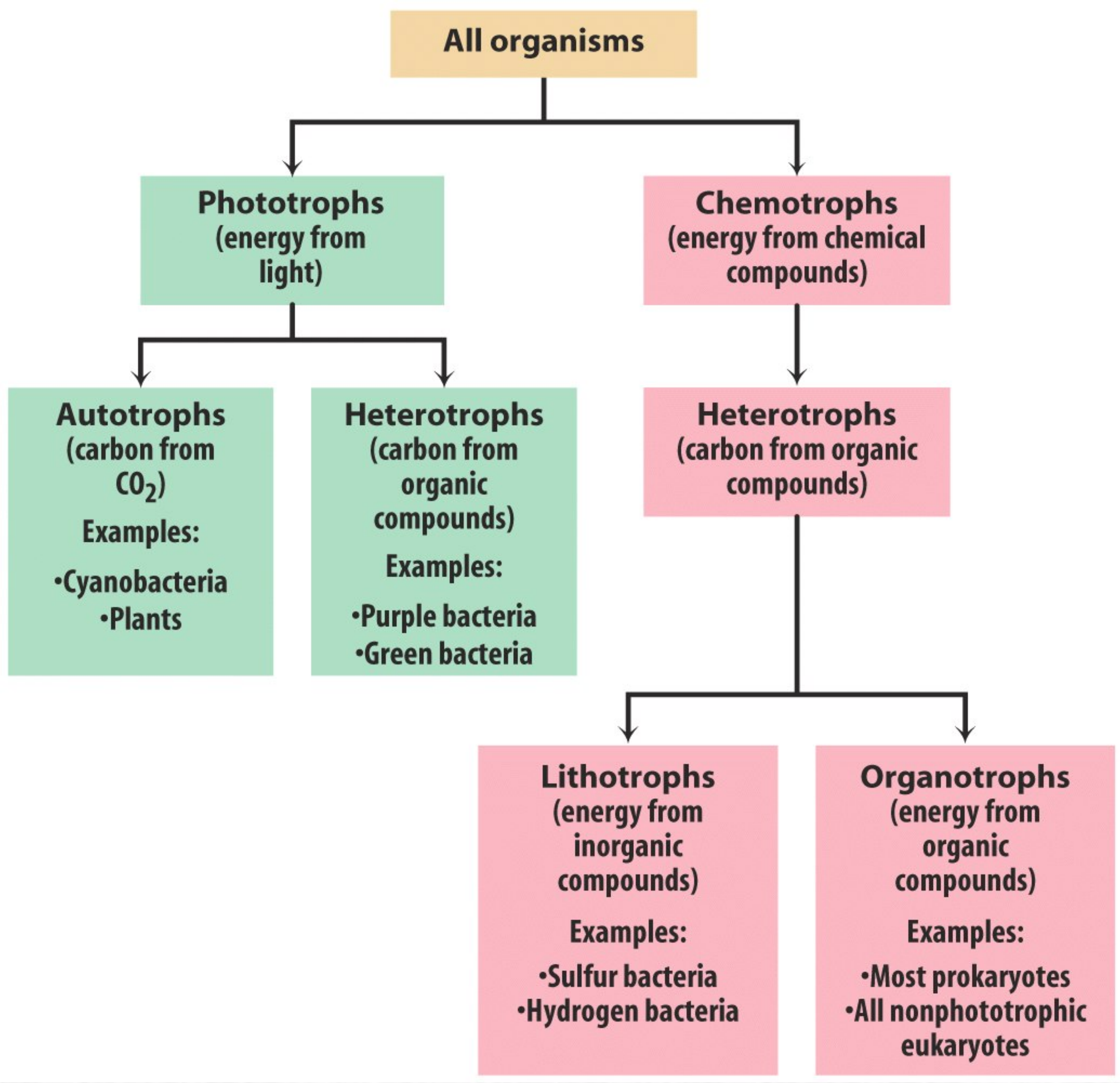
| *Characteristic* | *Prokaryotic cell* | *Eukaryotic cell* |
|---|---|---|
| Size | Generally small (1–10 $\mu$m) | Generally large (5–100 $\mu$m) |
| Genome | DNA with nonhistone protein; genome in nucleoid, not surrounded by membrane | DNA complexed with histone and nonhistone proteins in chromosomes; chromosomes in nucleus with membranous envelope |
| Cell division | Fission or budding; no mitosis | Mitosis, including mitotic spindle; centrioles in many species |
| Membrane-bounded organelles | Absent | Mitochondria, chloroplasts (in plants, some algae), endoplasmic reticulum, Golgi complexes, lysosomes (in animals), etc. |
| Nutrition | Absorption; some photosynthesis | Absorption, ingestion; photosynthesis in some species |
| Energy metabolism | No mitochondria; oxidative enzymes bound to plasma membrane; great variation in metabolic pattern | Oxidative enzymes packaged in mitochondria; more unified pattern of oxidative metabolism |
| Cytoskeleton | None | Complex, with microtubules, intermediate filaments, actin filaments |
| Intracellular movement | None | Cytoplasmic streaming, endocytosis, phagocytosis, mitosis, vesicle transport |

*Table 13-1.* **Metabolic Functions of Eukaryotic Organelles**

| *Organelle* | *Function* |
|---|---|
| Mitochondrion | Citric acid cycle, oxidative phosphorylation, fatty acid oxidation, amino acid breakdown |
| Cytosol | Glycolysis, pentose phosphate pathway, fatty acid biosynthesis, many reactions of gluconeogenesis |
| Lysosomes | Enzymatic digestion of cell components and ingested matter |
| Nucleus | DNA replication and transcription, RNA processing |
| Golgi apparatus | Posttranslational processing of membrane and secretory proteins; formation of plasma membrane and secretory vesicles |
| Rough endoplasmic reticulum | Synthesis of membrane-bound and secretory proteins |
| Smooth endoplasmic reticulum | Lipid and steroid biosynthesis |
| Peroxisomes (glyoxysomes in plants) | Oxidative reactions catalyzed by amino acid oxidases and catalase; glyoxylate cycle reactions in plants |

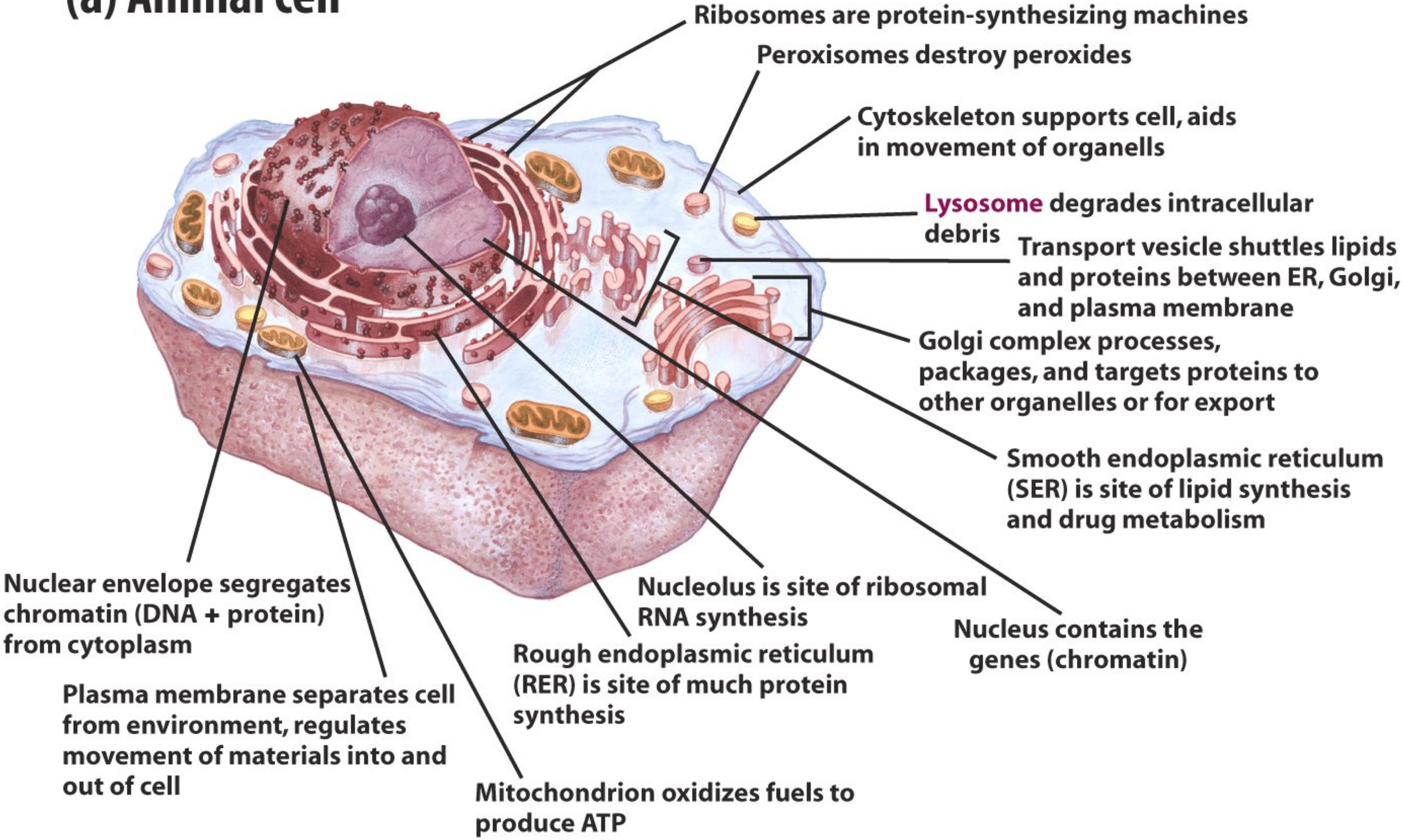
**TABLE 1–2** **Molecular Components of an *E. coli* Cell**

| | *Percentage of total weight of cell* | *Approximate number of different molecular species* |
|---|---|---|
| Water | 70 | 1 |
| Proteins | 15 | 3,000 |
| Nucleic acids | | |
| DNA | 1 | 1 |
| RNA | 6 | >3,000 |
| Polysaccharides | 3 | 5 |
| Lipids | 2 | 20 |
| Monomeric subunits and intermediates | 2 | 500 |
| Inorganic ions | 1 | 20 |

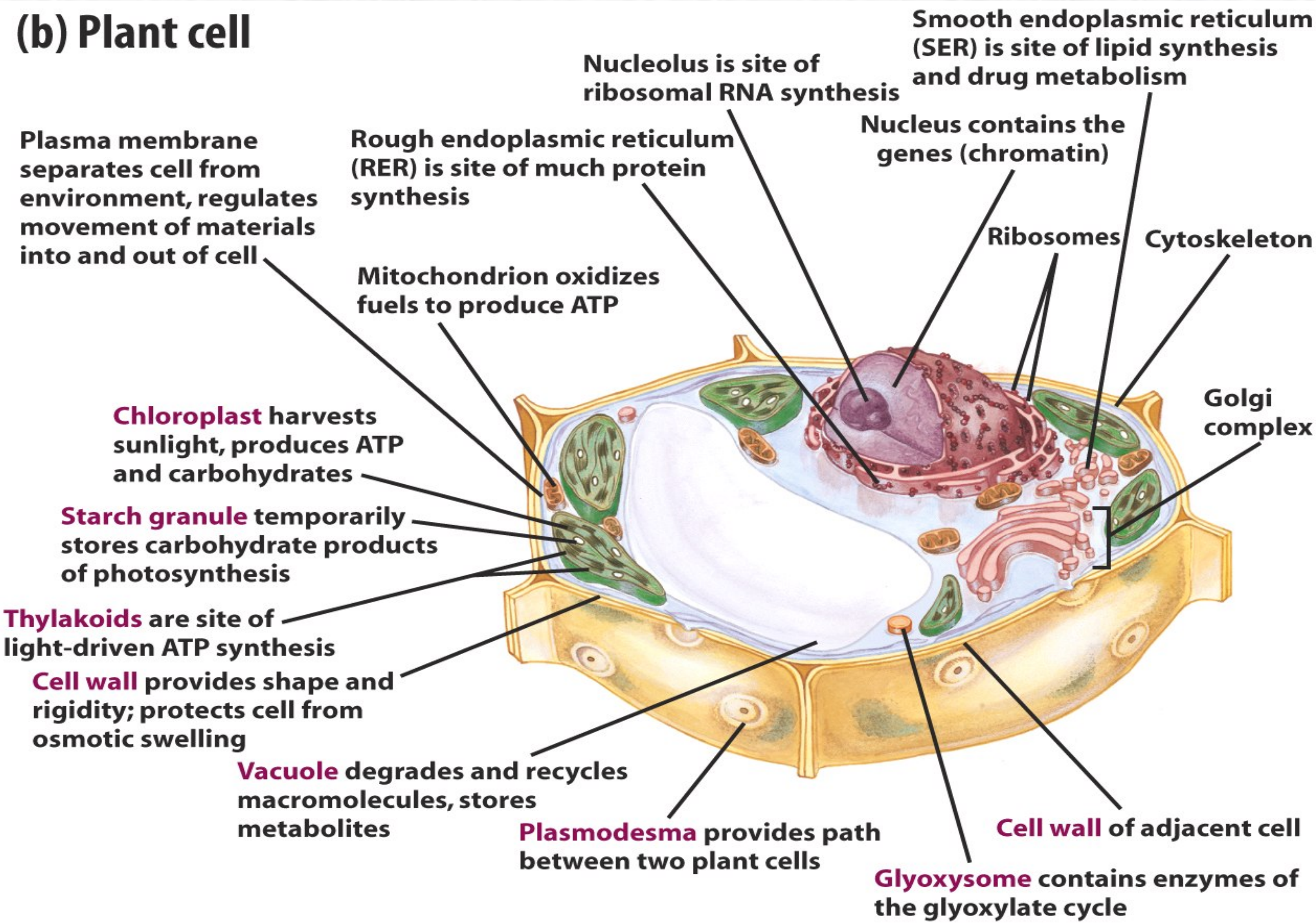


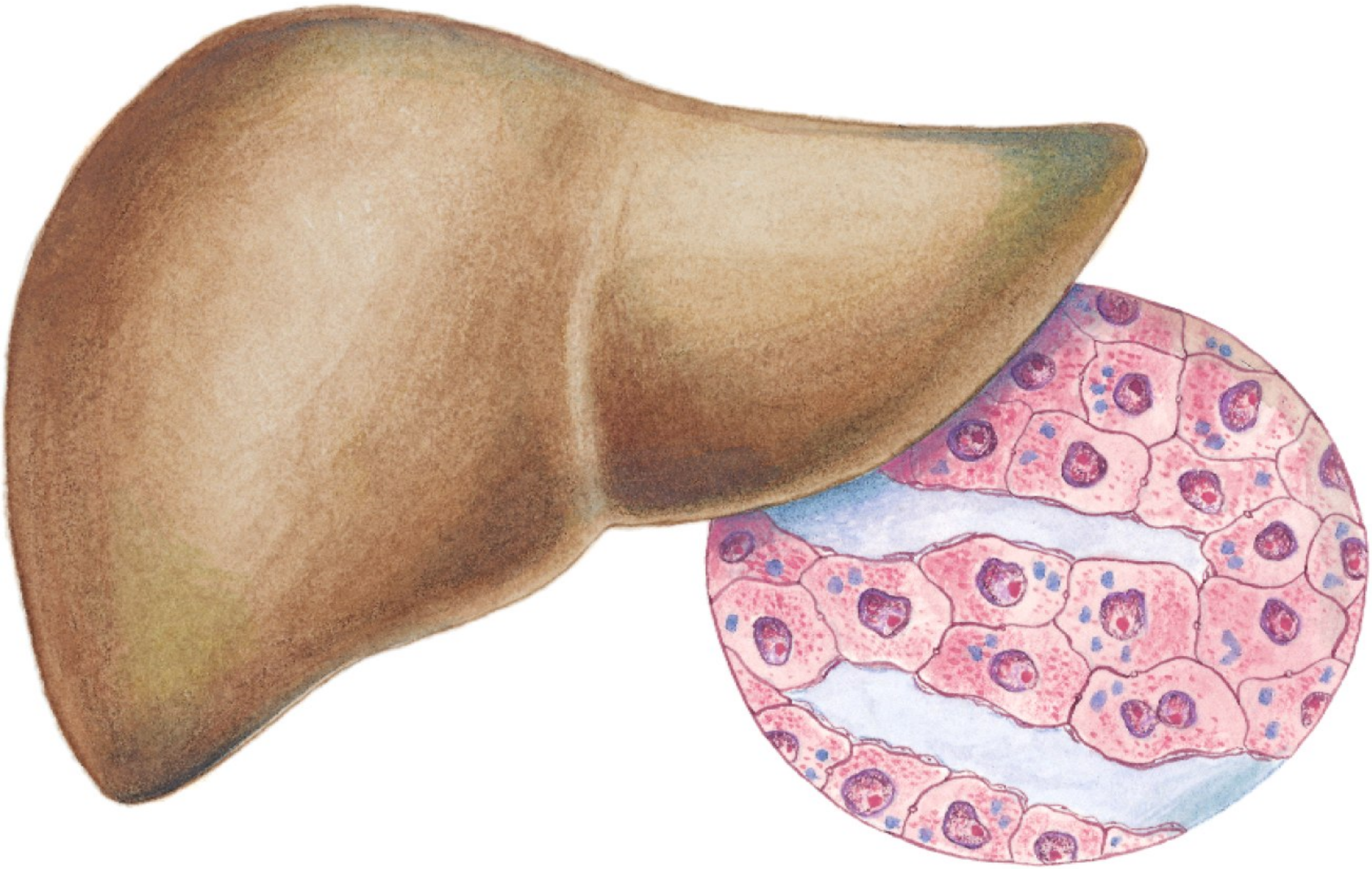
All organisms
Phototrophs (energy from light)
Chemotrophs (energy from chemical compounds)
Autotrophs (carbon from $CO_2$)
Examples:
•Cyanobacteria
•Plants
Heterotrophs (carbon from organic compounds)
Examples:
•Purple bacteria
•Green bacteria
Heterotrophs (carbon from organic compounds)
Lithotrophs (energy from inorganic compounds)
Examples:
•Sulfur bacteria
•Hydrogen bacteria
Organotrophs (energy from organic compounds)
Examples:
•Most prokaryotes
•All nonphototrophic eukaryotes

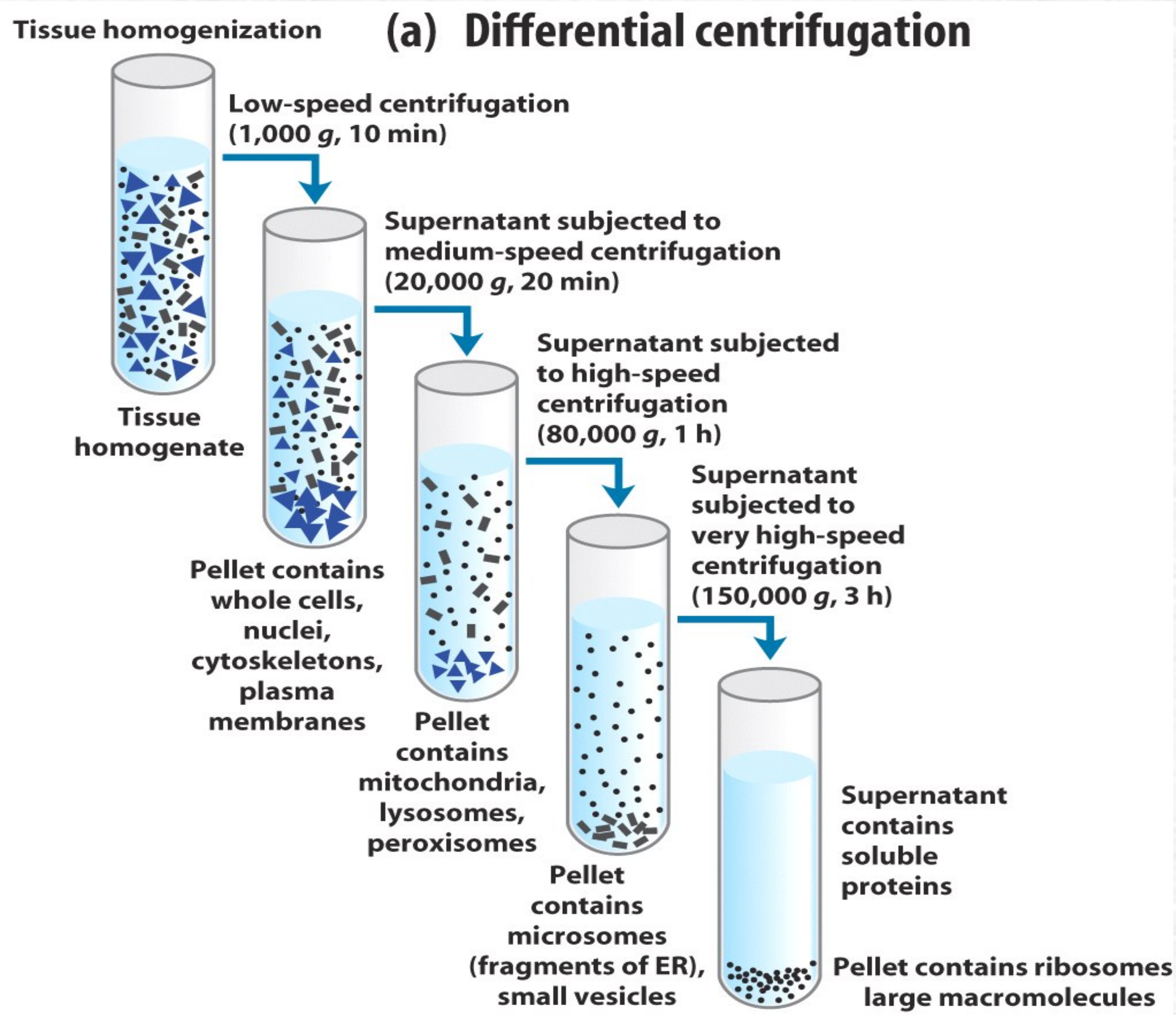
## (a) Animal cell

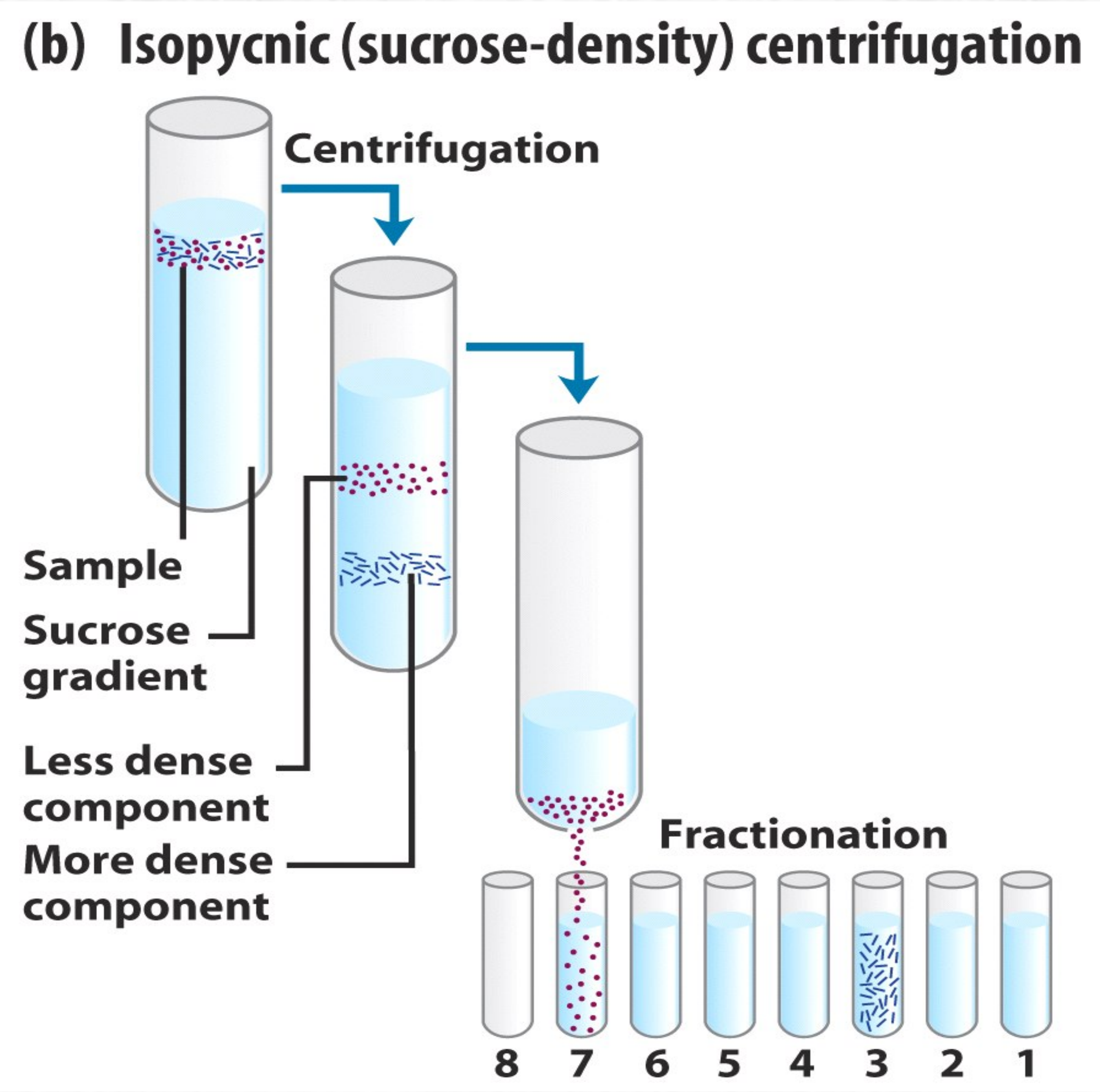


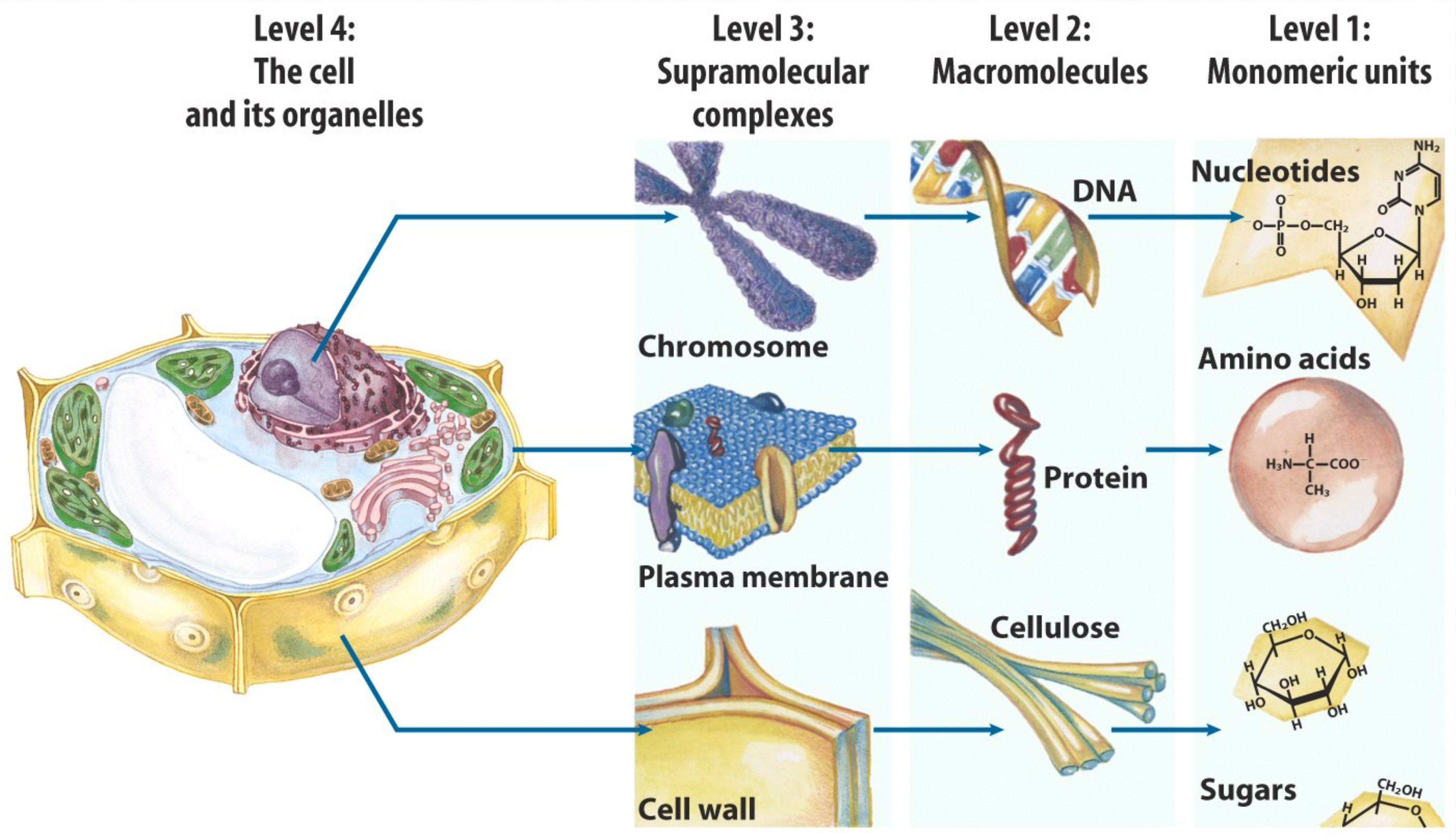
# (b) Plant cell


Smooth endoplasmic reticulum (SER) is site of lipid synthesis and drug metabolism
Nucleolus is site of ribosomal RNA synthesis
Plasma membrane separates cell from environment, regulates movement of materials into and out of cell
Rough endoplasmic reticulum (RER) is site of much protein synthesis
Nucleus contains the genes (chromatin)
Ribosomes
Cytoskeleton
Mitochondrion oxidizes fuels to produce ATP
Golgi complex
Chloroplast harvests sunlight, produces ATP and carbohydrates
Starch granule temporarily stores carbohydrate products of photosynthesis
Thylakoids are site of light-driven ATP synthesis
Cell wall provides shape and rigidity; protects cell from osmotic swelling
Vacuole degrades and recycles macromolecules, stores metabolites
Plasmodesma provides path between two plant cells
Cell wall of adjacent cell
Glyoxysome contains enzymes of the glyoxylate cycle




Tissue homogenization
(a) Differential centrifugation
Low-speed centrifugation (1,000 g, 10 min)
Tissue homogenate
Supernatant subjected to medium-speed centrifugation (20,000 g, 20 min)
Pellet contains whole cells, nuclei, cytoskeletons, plasma membranes
Supernatant subjected to high-speed centrifugation (80,000 g, 1 h)
Pellet contains mitochondria, lysosomes, peroxisomes
Supernatant subjected to very high-speed centrifugation (150,000 g, 3 h)
Pellet contains microsomes (fragments of ER), small vesicles
Supernatant contains soluble proteins
Pellet contains ribosomes large macromolecules


(b) Isopycnic (sucrose-density) centrifugation
Centrifugation
Sample
Sucrose gradient
Less dense component
More dense component
Fractionation
8
7
6
5
4
3
2
1

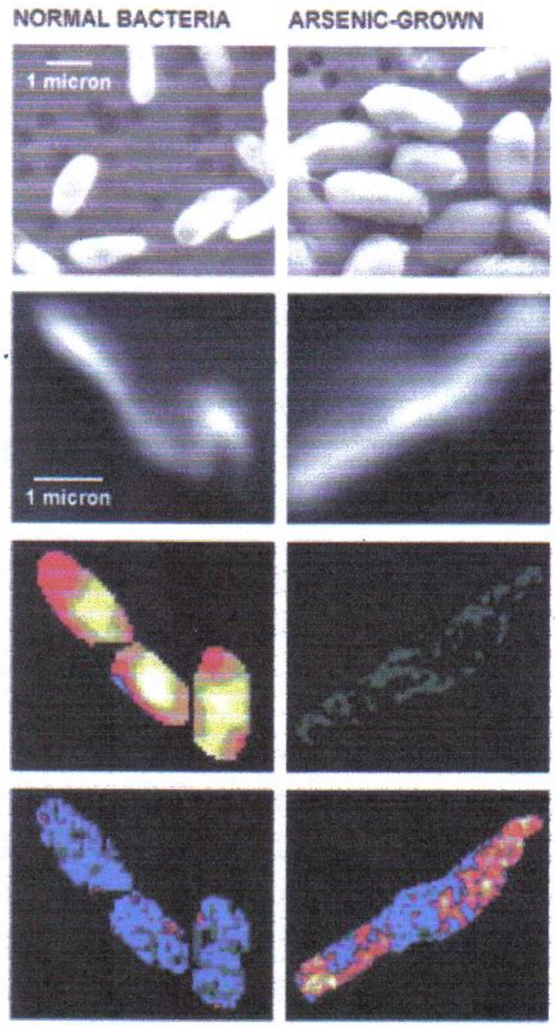

Level 4:
The cell
and its organelles
Level 3:
Supramolecular
complexes
Level 2:
Macromolecules
Level 1:
Monomeric units
Chromosome
DNA
Nucleotides
Plasma membrane
Protein
Amino acids
Cell wall
Cellulose
Sugars

Six elements are the most essential for life: C, H, O, N, P, S
A microbe in California can substitute As for P as part of DNA

The New York Times
December 3, 2010

## Grown in Arsenic

Researchers isolated arsenic-tolerant bacteria from Mono Lake, an ancient and alkaline California lake. The bacteria were gradually starved of phosphorus, an element thought to be essential for life, and fed more and more arsenic. Over time the bacteria began to grow and multiply by replacing the phosphorus in their bodies with arsenic atoms.




At right, images of several normal and arsenic-grown bacteria. The arsenic-grown microbes appear larger because the extra arsenic seems to make them grow empty internal spaces.

At right, images of two individual microbes. The researchers used radioactive tracers to detect the relative amounts of phosphorus and arsenic in each bacterium.

The normal bacterium has high levels of phosphorus, while the arsenic-grown one has almost none.

*Amount of phosphorus* None — High

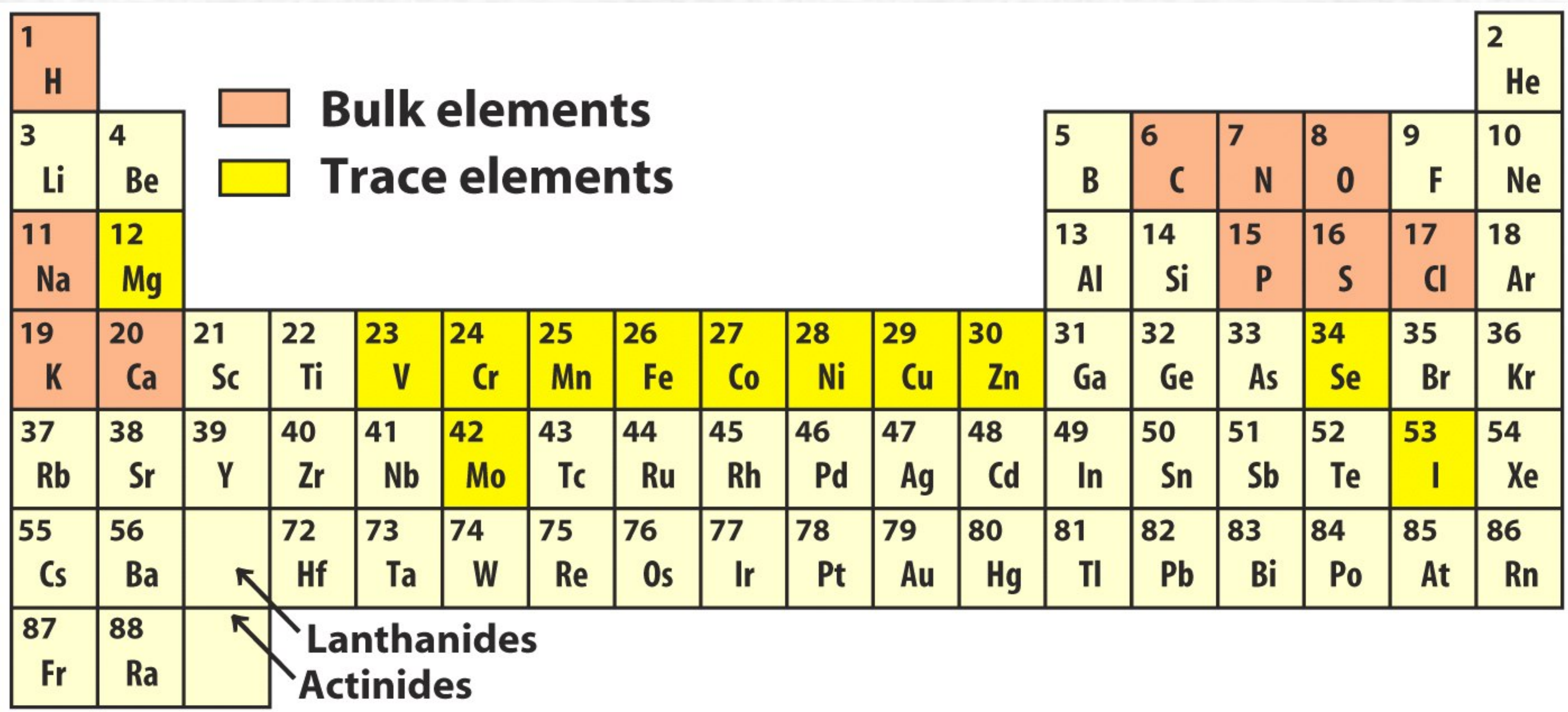
The normal bacterium also has low levels of arsenic, while the arsenic-grown one has much higher levels.

*Amount of arsenic* None — High

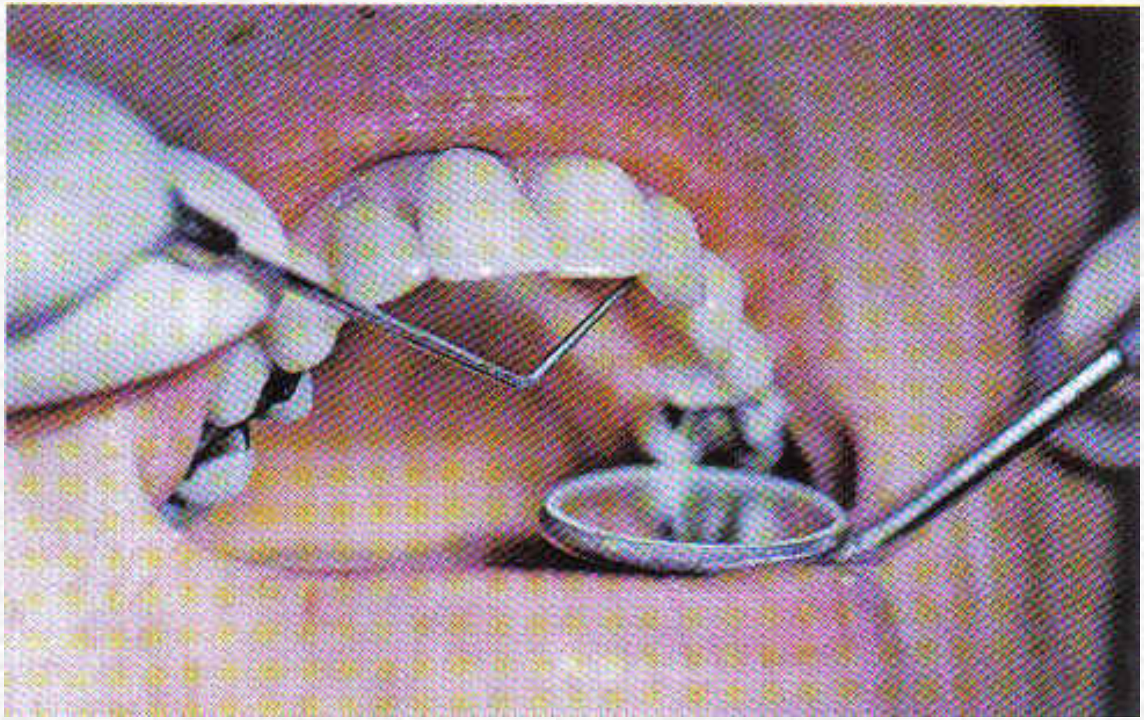
Source: Science

THE NEW YORK TIMES; IMAGES BY SCIENCE

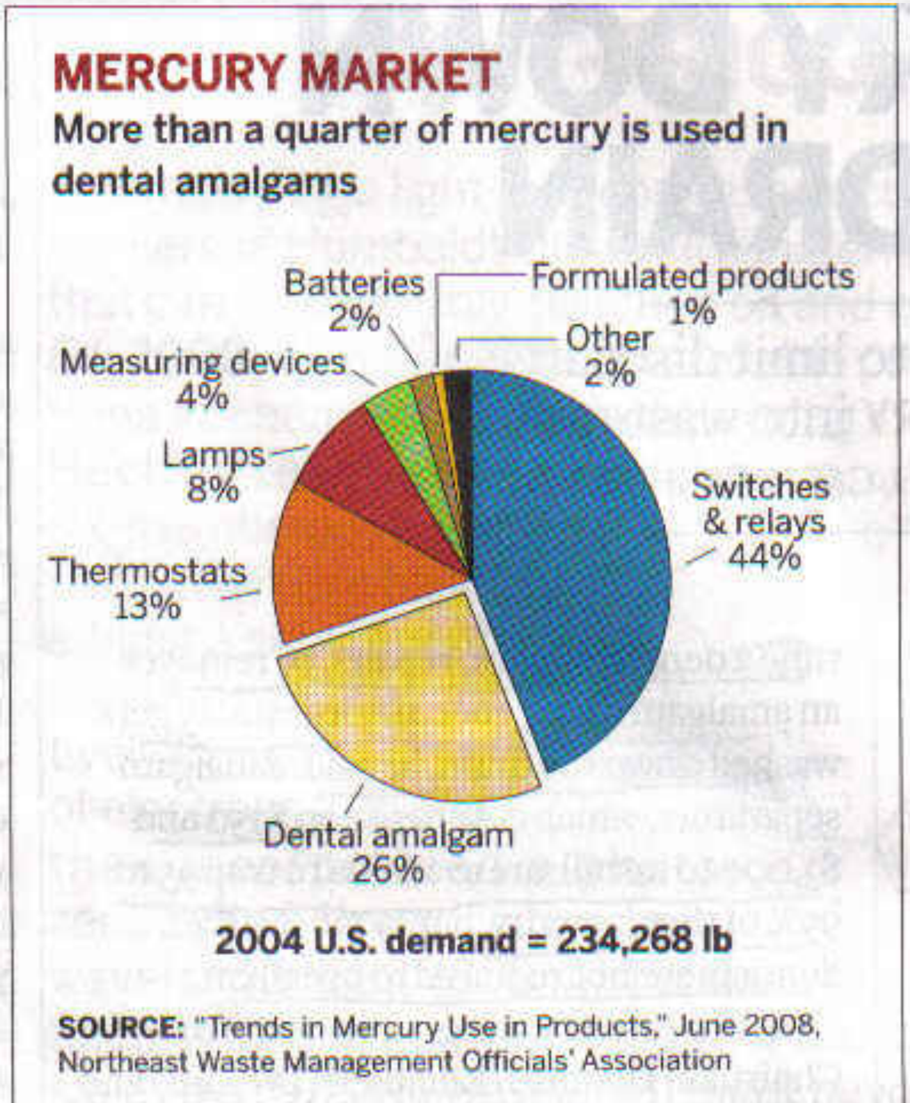
RECOMMEND


Bulk elements
Trace elements
1 H
2 He
3 Li
4 Be
5 B
6 C
7 N
8 O
9 F
10 Ne
11 Na
12 Mg
13 Al
14 Si
15 P
16 S
17 Cl
18 Ar
19 K
20 Ca
21 Sc
22 Ti
23 V
24 Cr
25 Mn
26 Fe
27 Co
28 Ni
29 Cu
30 Zn
31 Ga
32 Ge
33 As
34 Se
35 Br
36 Kr
37 Rb
38 Sr
39 Y
40 Zr
41 Nb
42 Mo
43 Tc
44 Ru
45 Rh
46 Pd
47 Ag
48 Cd
49 In
50 Sn
51 Sb
52 Te
53 I
54 Xe
55 Cs
56 Ba
72 Hf
73 Ta
74 W
75 Re
76 Os
77 Ir
78 Pt
79 Au
80 Hg
81 Tl
82 Pb
83 Bi
84 Po
85 At
86 Rn
87 Fr
88 Ra
Lanthanides
Actinides

# Hg- Americans are walking around with more than 1,000 tons of mercury in their mouths



Chem & Eng News 7/28/08




Amalgam separators are available for between $750 and $3,000 which can trap about 95 – 99% of Hg in drain wash but most states do not require them.

# Ultimate Disposal of Mercury in Teeth (what happens to fillings in cremated corpses?)

Crematoria in Europe must filter Hg released from dental amalgams; In the US the EPI does not regulate Hg emissions from smokestacks however about 6,600 #'s (3.3 tons) of Hg were released into the environment in 2005.

This problem may last until about 2055 when Hg fillings fall out of use.

Ref. Chem & Eng News June 28, 2010 p 41

- So if there may be a problem with amalgams, what other options are available?
- Resin-based dental materials can be used but these commonly contain Bisphenol A (BPA) which can be intra-orally released from the biting surface of the teeth.
- Children with higher cumulative exposure to BPA derivatives demonstrated impaired psychosocial behavior compared to children treated with amalgams. (Ref. Pediatrics 2011-3374)
- Lesson: BE AWARE of RISK OF FILLING TYPE

## BIOMOLECULES

## KEY TERMS

Functional Groups: Groups of atoms added to carbon skeletons, which confer specific properties in the molecule.

Stereoisomers - order of bonding is the same but special relationship between atoms is different.

Geometric (cis-trans) - differ in arrangement of substituent groups around double bond.

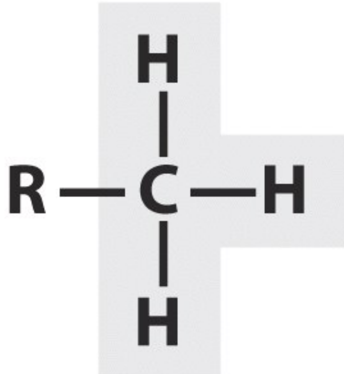
Chiral Center - Asymmetric carbon atom - i.e. 4 different substituents.

Enantiomers - mirror images

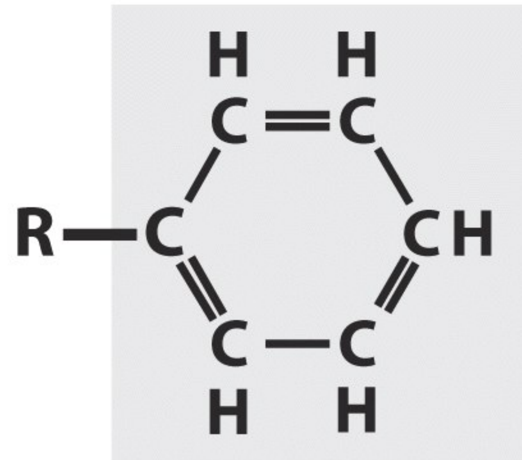
Diastereomers - non-mirror images

Racemic mixtures - no optical rotation

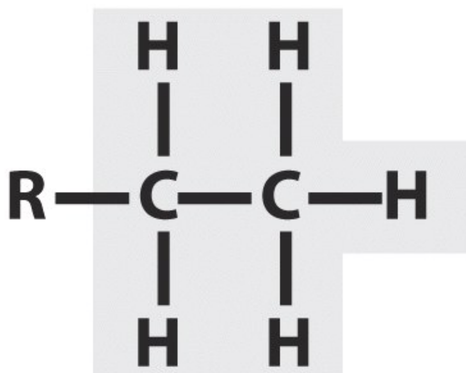
Methyl

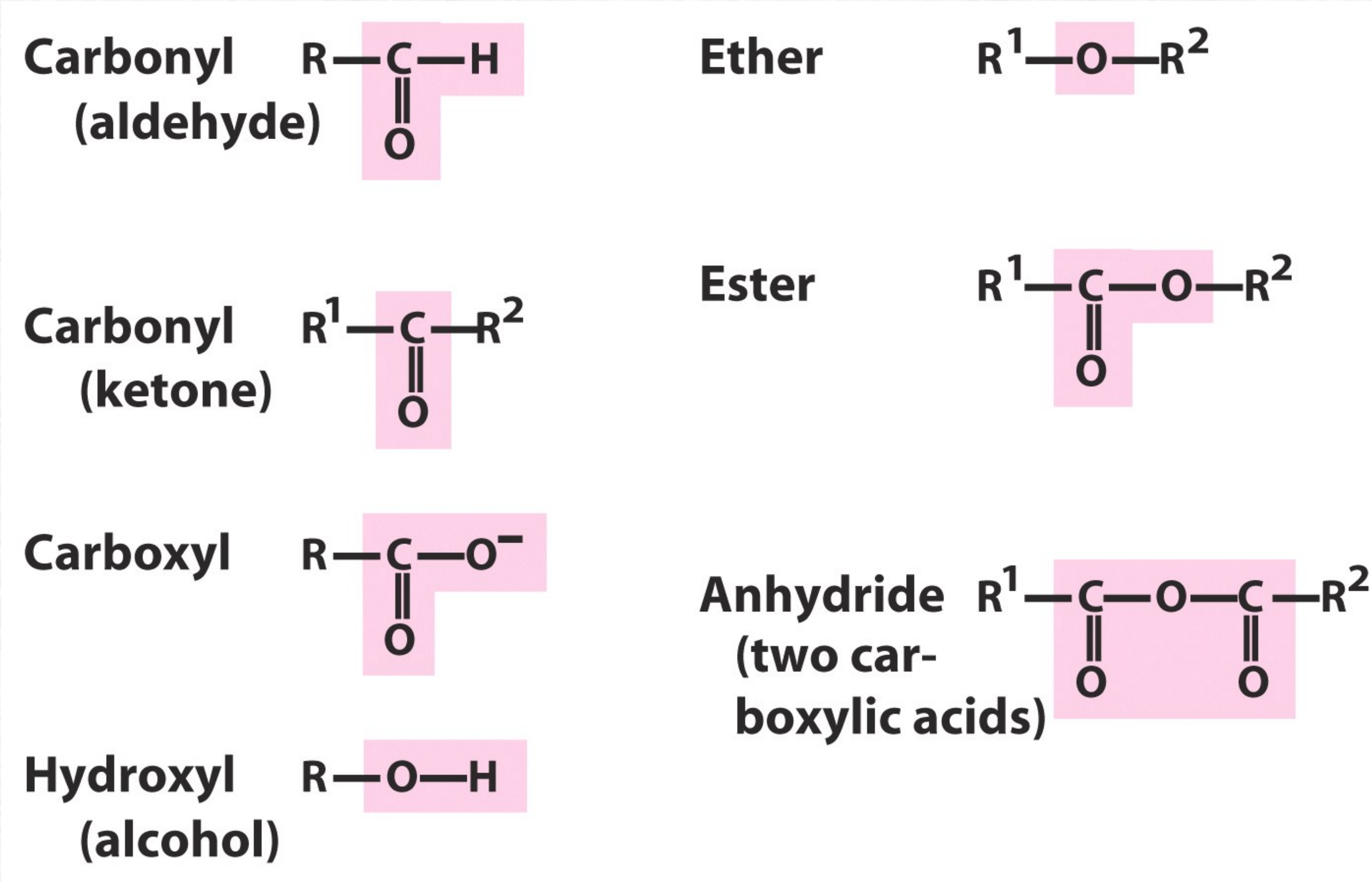


Phenyl

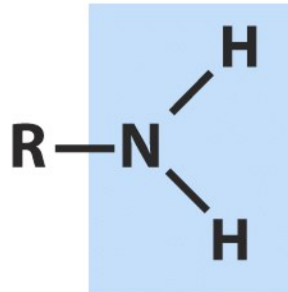


Ethyl

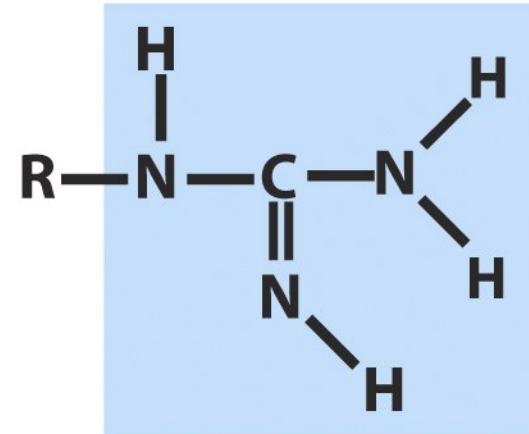



Carbonyl (aldehyde)
R—C—H
O
Carbonyl (ketone)
R1—C—R2
O
Carboxyl
R—C—O−
O
Hydroxyl (alcohol)
R—O—H
Ether
R1—O—R2
Ester
R1—C—O—R2
O
Anhydride (two carboxylic acids)
R1—C—O—C—R2
O
O

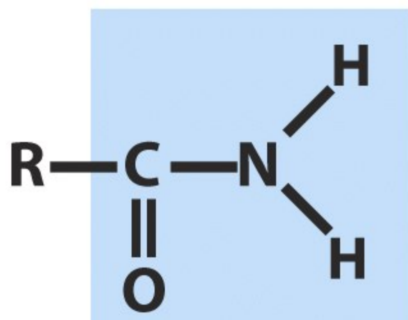
Amino



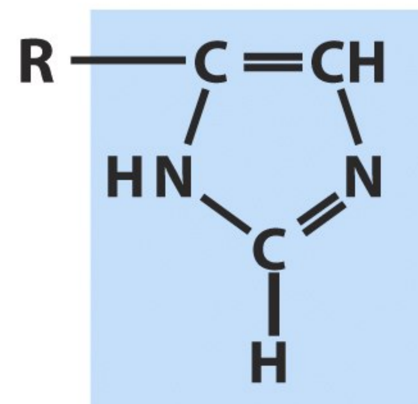
Guanidino



Amido



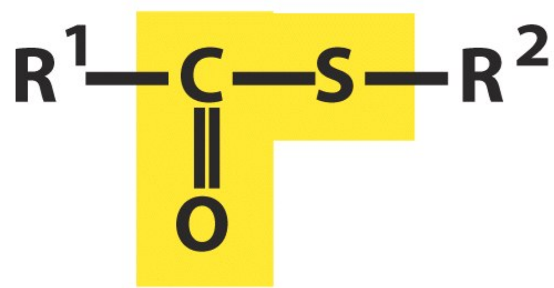
Imidazole



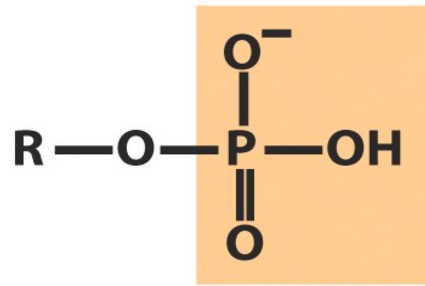
**Sulfhydryl**


**Disulfide**

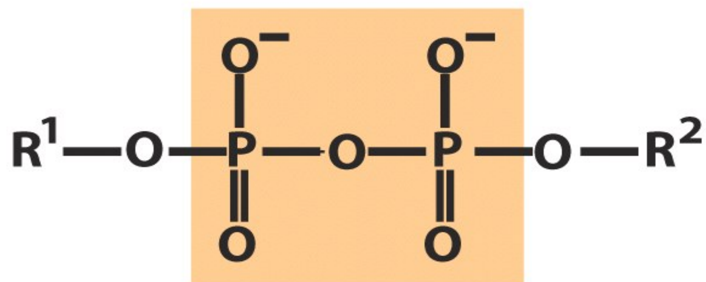

**Thioester**



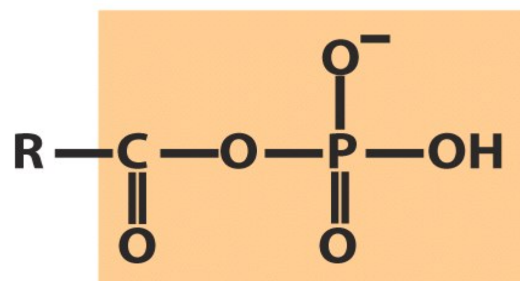
**Phosphoryl**

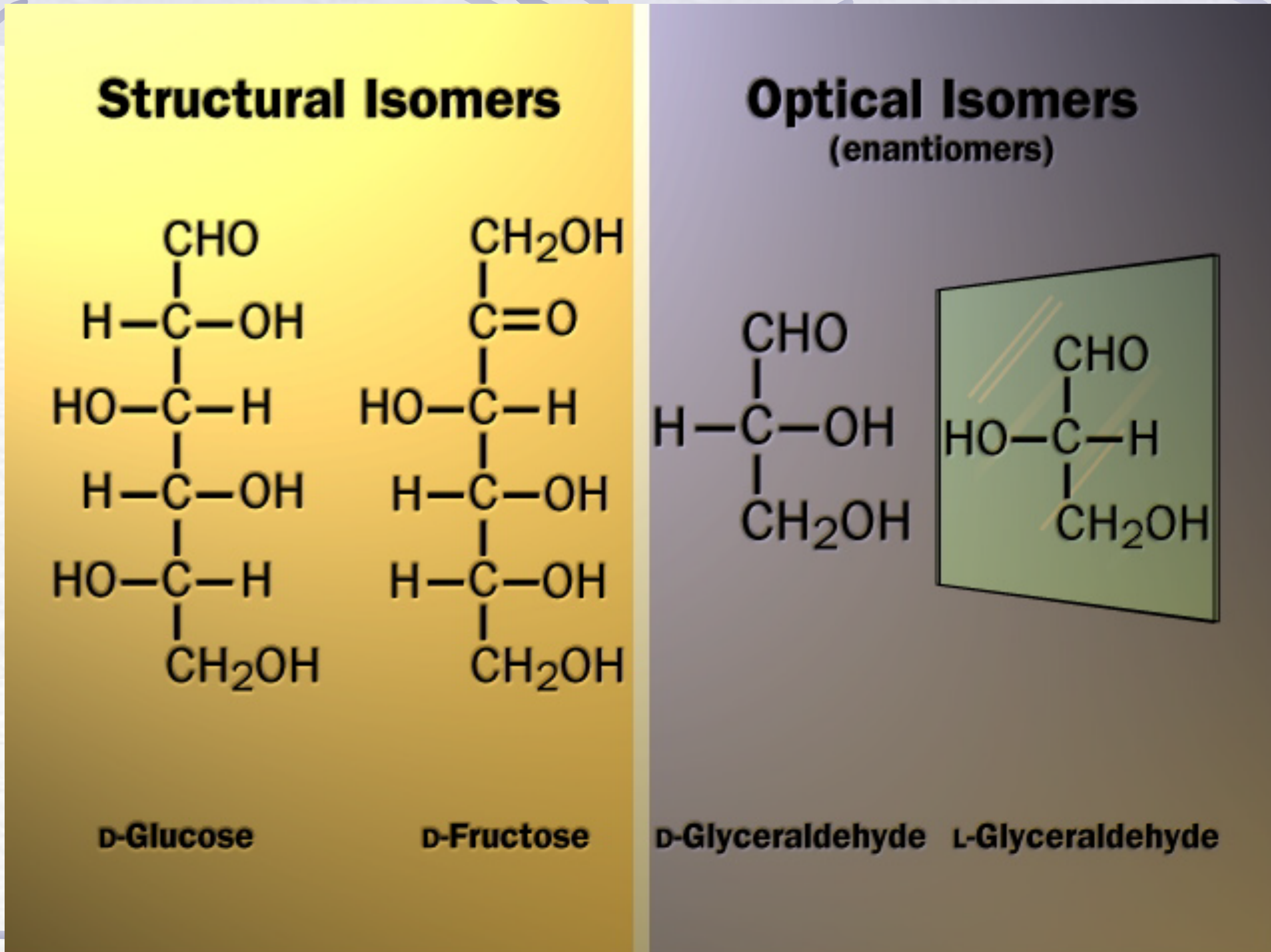


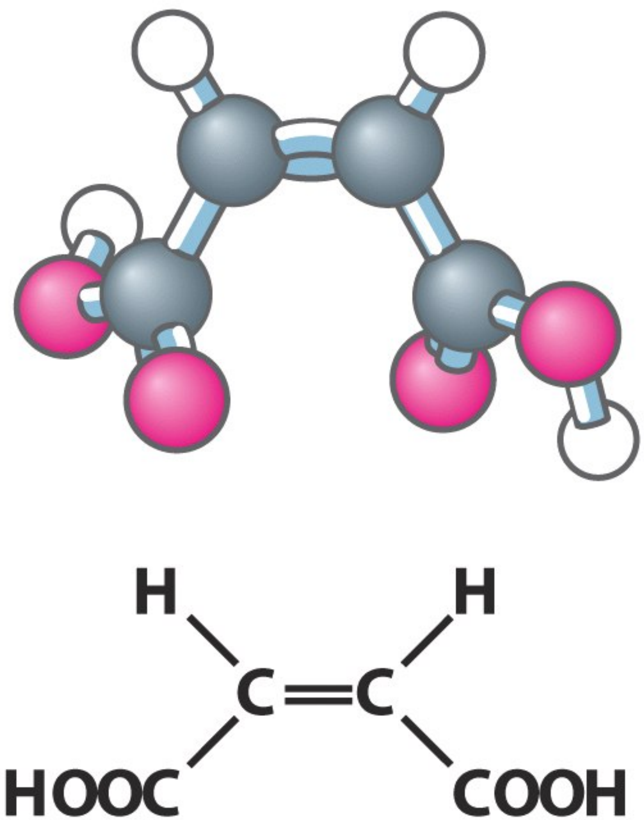
**Phosphoanhydride**



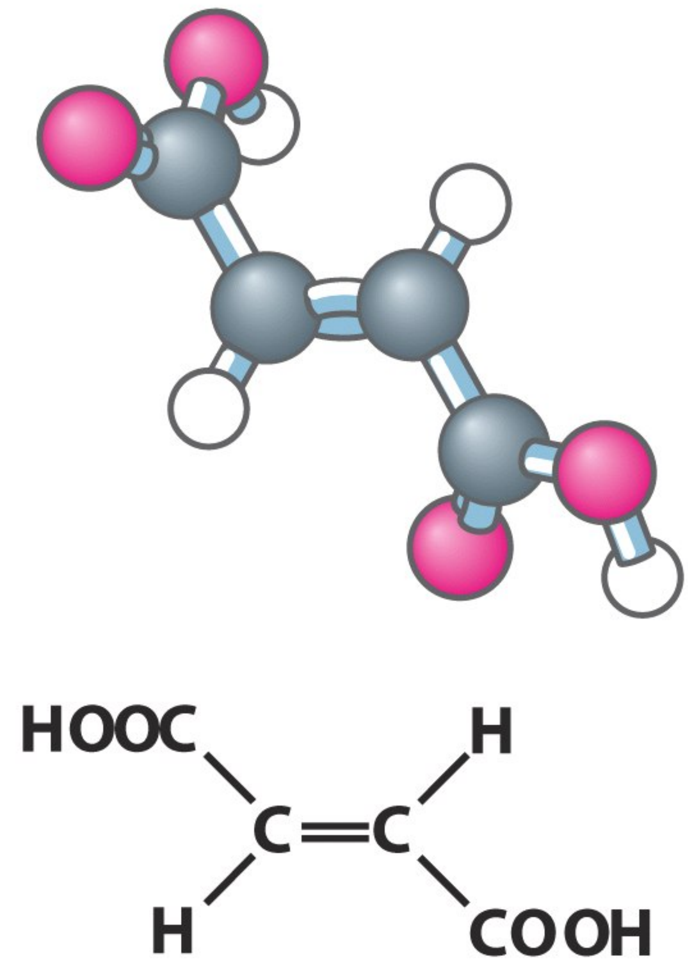
**Mixed anhydride**
**(carboxylic acid and phosphoric acid; also called acyl phosphate)**



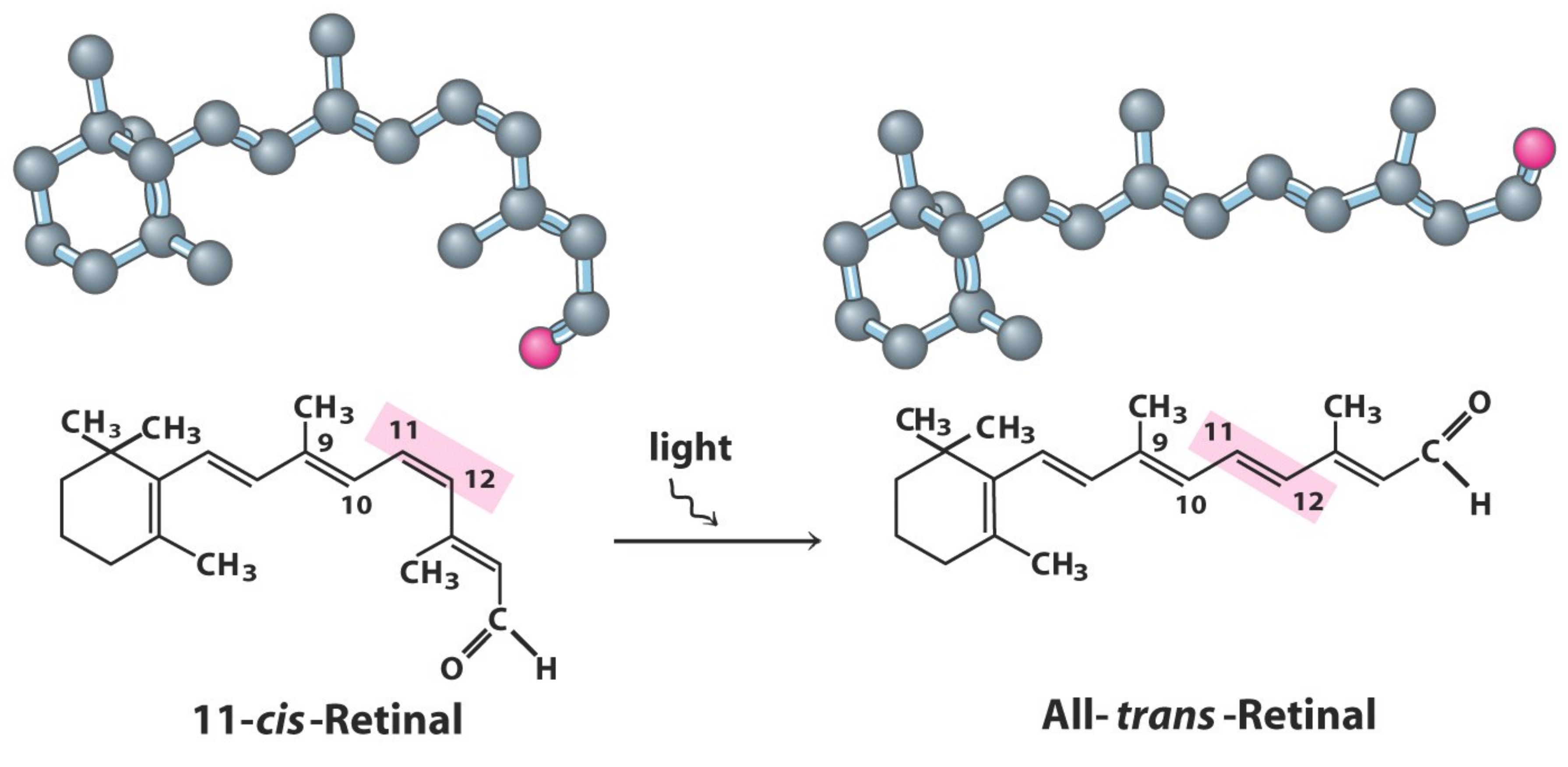

Structural Isomers
Optical Isomers
(enantiomers)
D-Glucose
D-Fructose
D-Glyceraldehyde
L-Glyceraldehyde



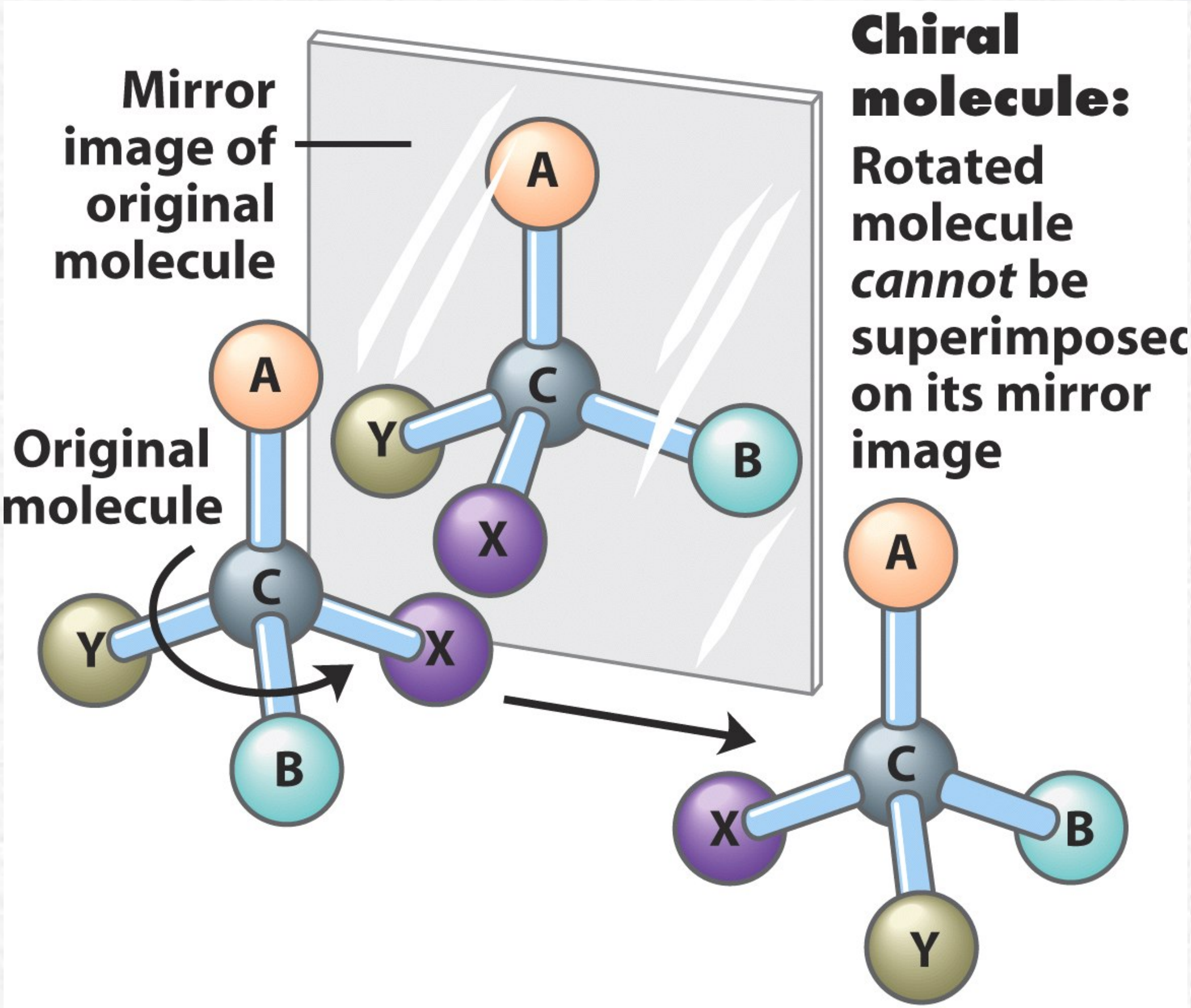

Maleic acid (cis)



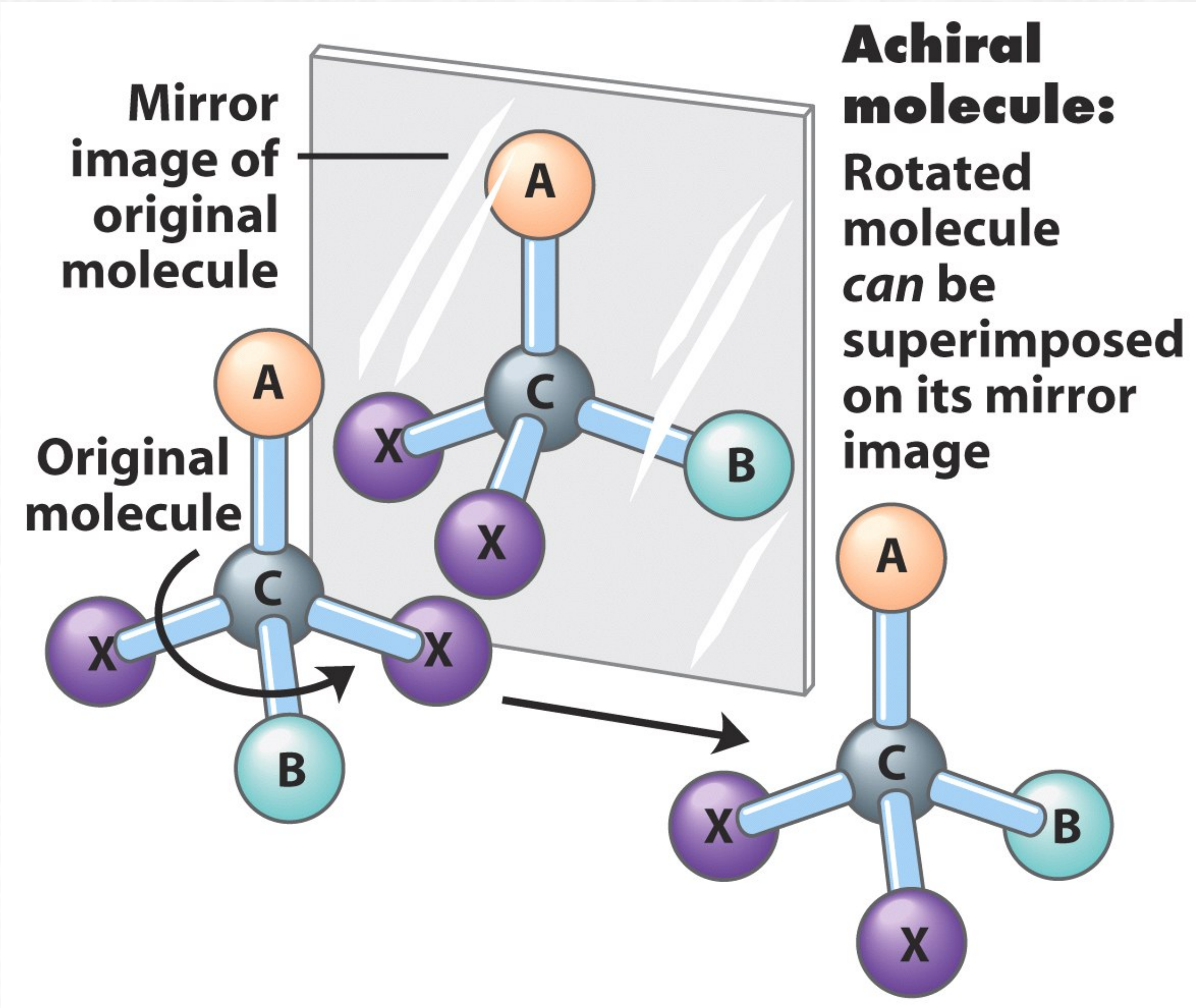

Fumaric acid (trans)

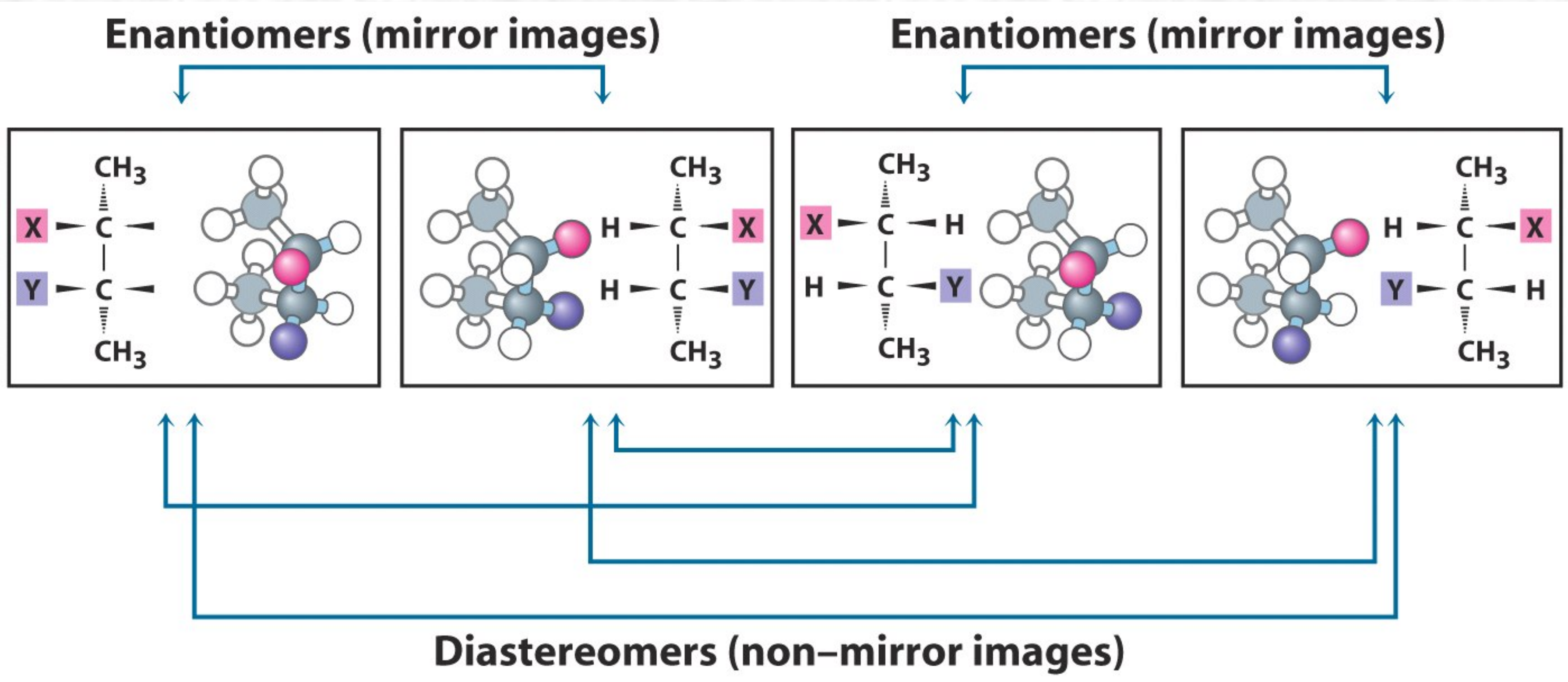


CH3
CH3
CH3
9
11
12
10
CH3
CH3
C
O
H
11-cis-Retinal
light
CH3
CH3
CH3
9
11
10
12
CH3
O
C
H
CH3
All-trans-Retinal

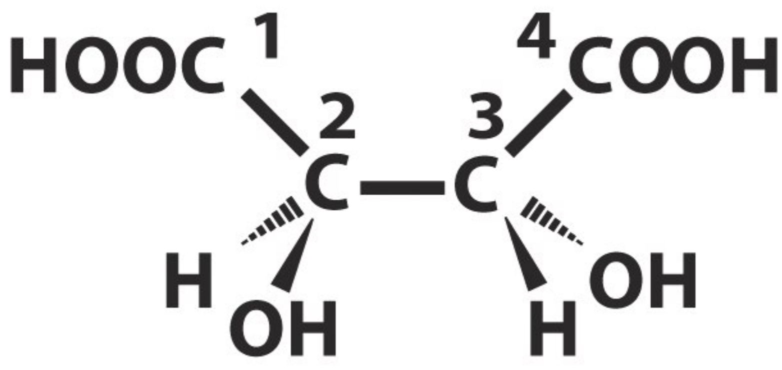


Chiral molecule:
Rotated molecule *cannot* be superimposed on its mirror image
Mirror image of original molecule
Original molecule
A
C
B
X
Y

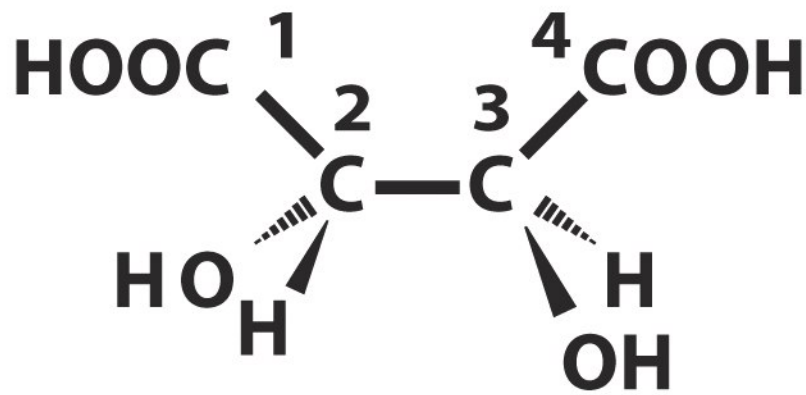

Mirror image of original molecule
Original molecule
Achiral molecule:
Rotated molecule *can* be superimposed on its mirror image
A
C
X
X
B
A
C
X
X
B
A
C
X
B
X



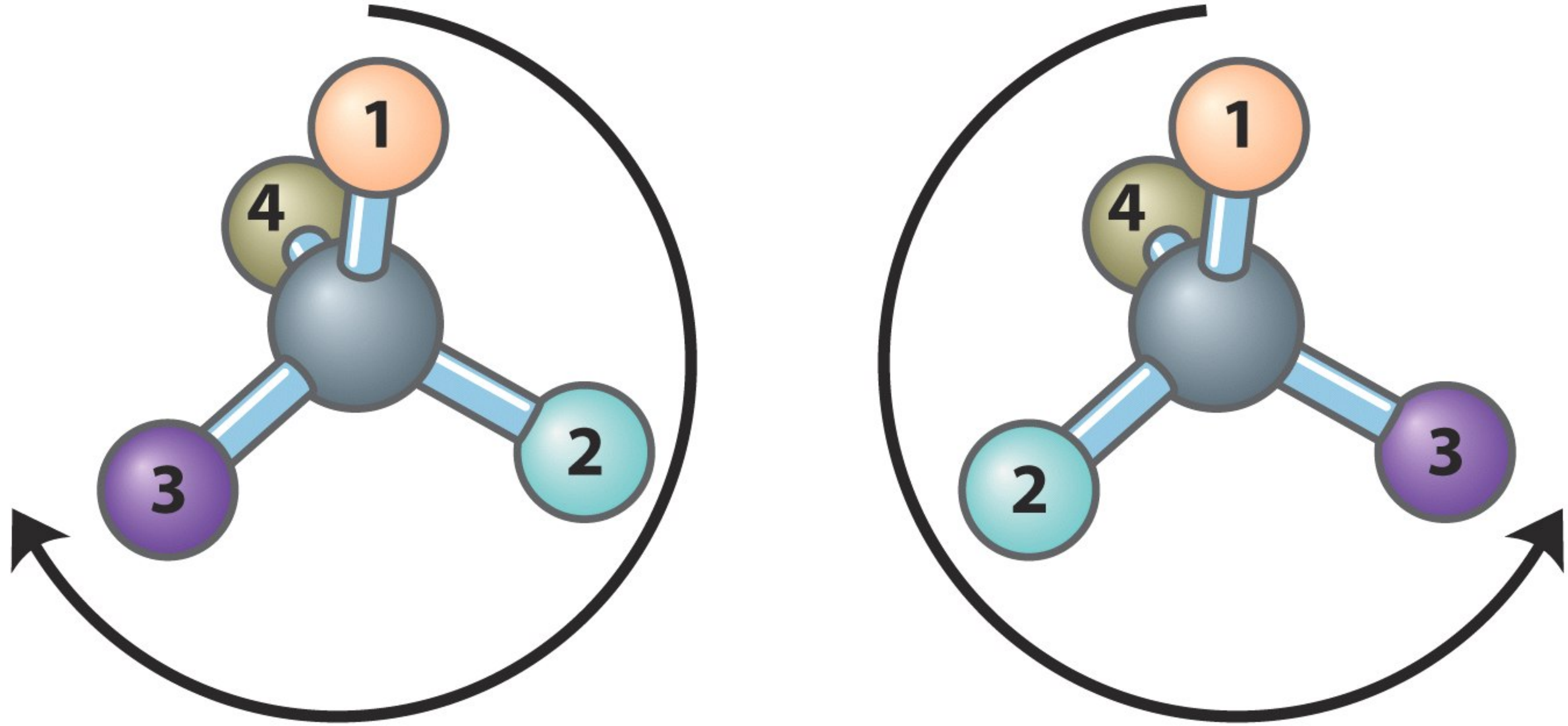
Enantiomers (mirror images)
Enantiomers (mirror images)
CH3
X
C
Y
C
CH3
CH3
H
C
X
H
C
Y
CH3
CH3
X
C
H
H
C
Y
CH3
CH3
H
C
X
Y
C
H
CH3
Diastereomers (non–mirror images)




(2*R*,3*R*)-Tartaric acid
(dextrorotatory)

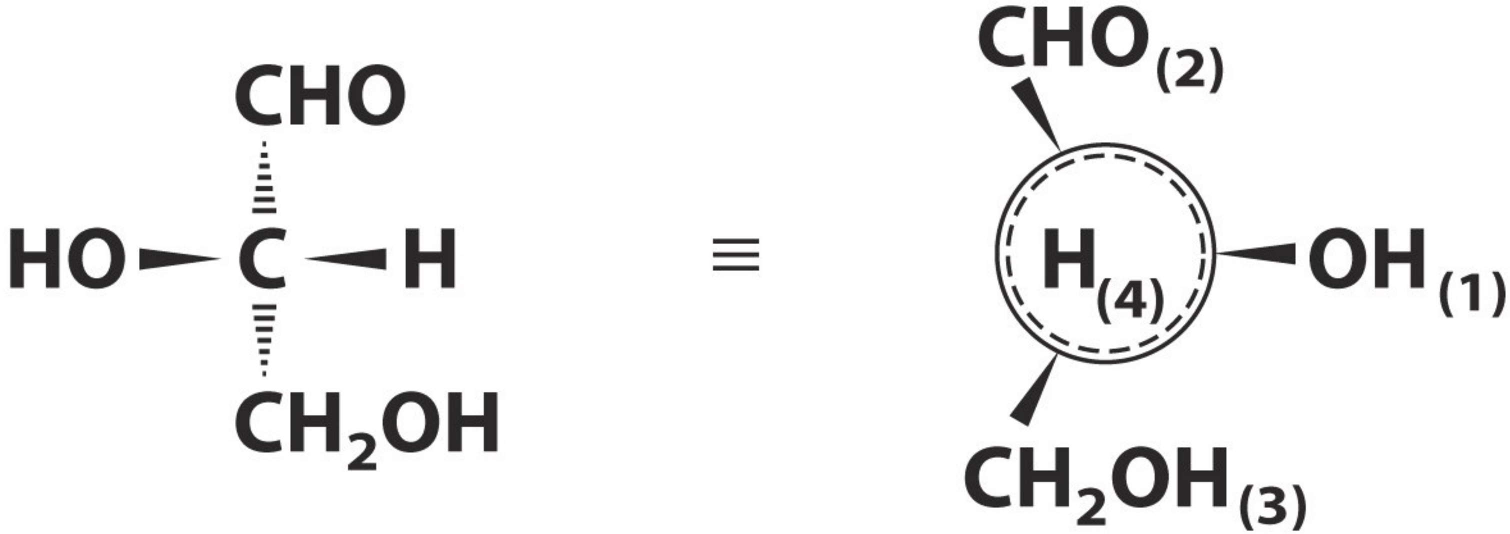



(2*S*,3*S*)-Tartaric acid
(levorotatory)

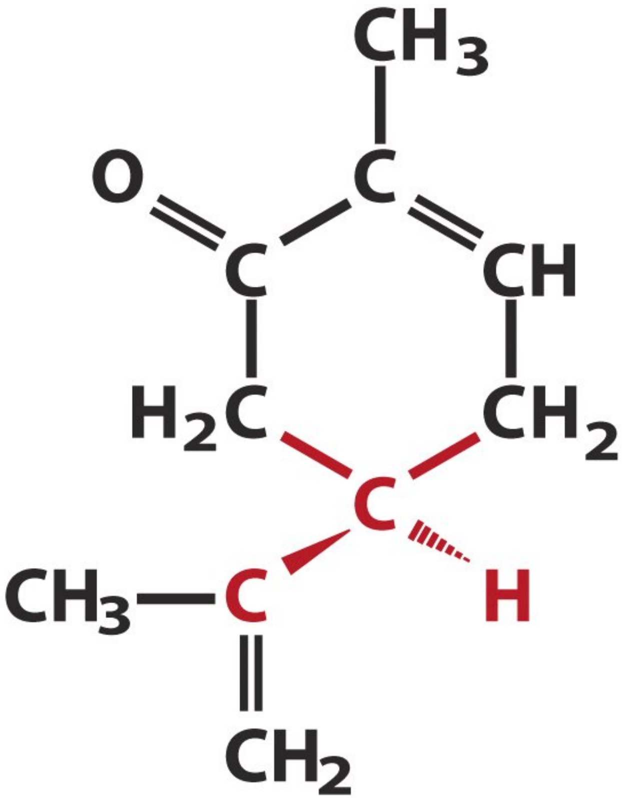



Clockwise
(*R*)

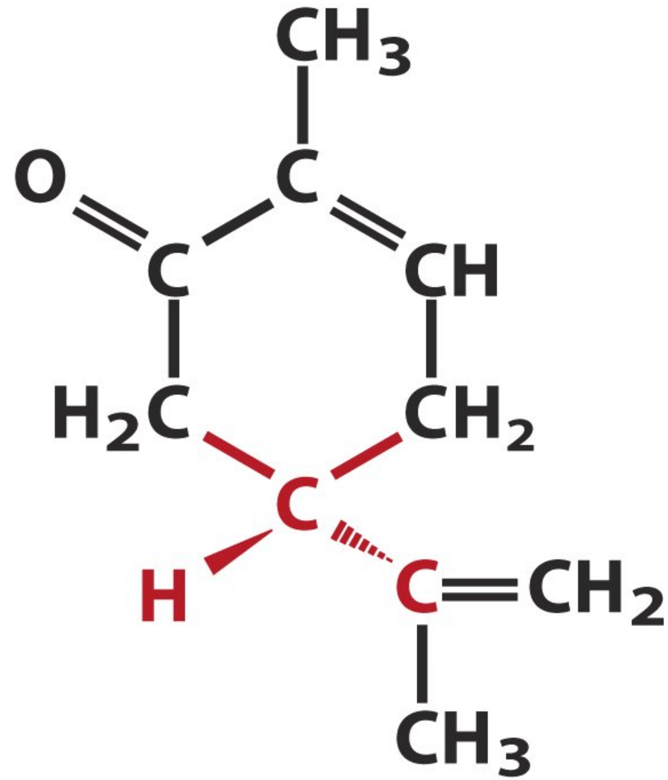
Counterclockwise
(*S*)



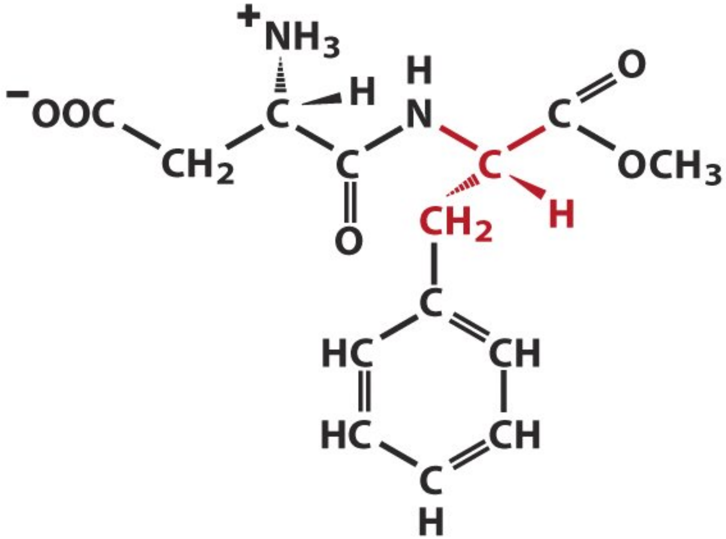

L-Glyceraldehyde (S)-Glyceraldehyde



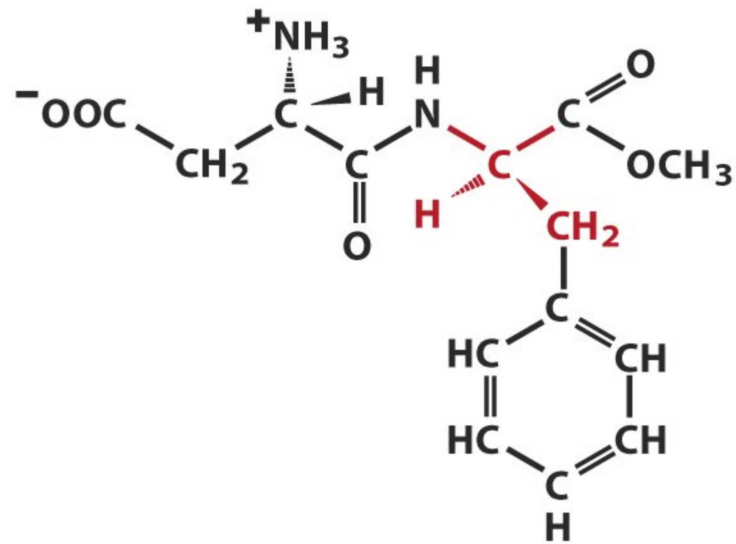

(*R*)-Carvone
(spearmint)



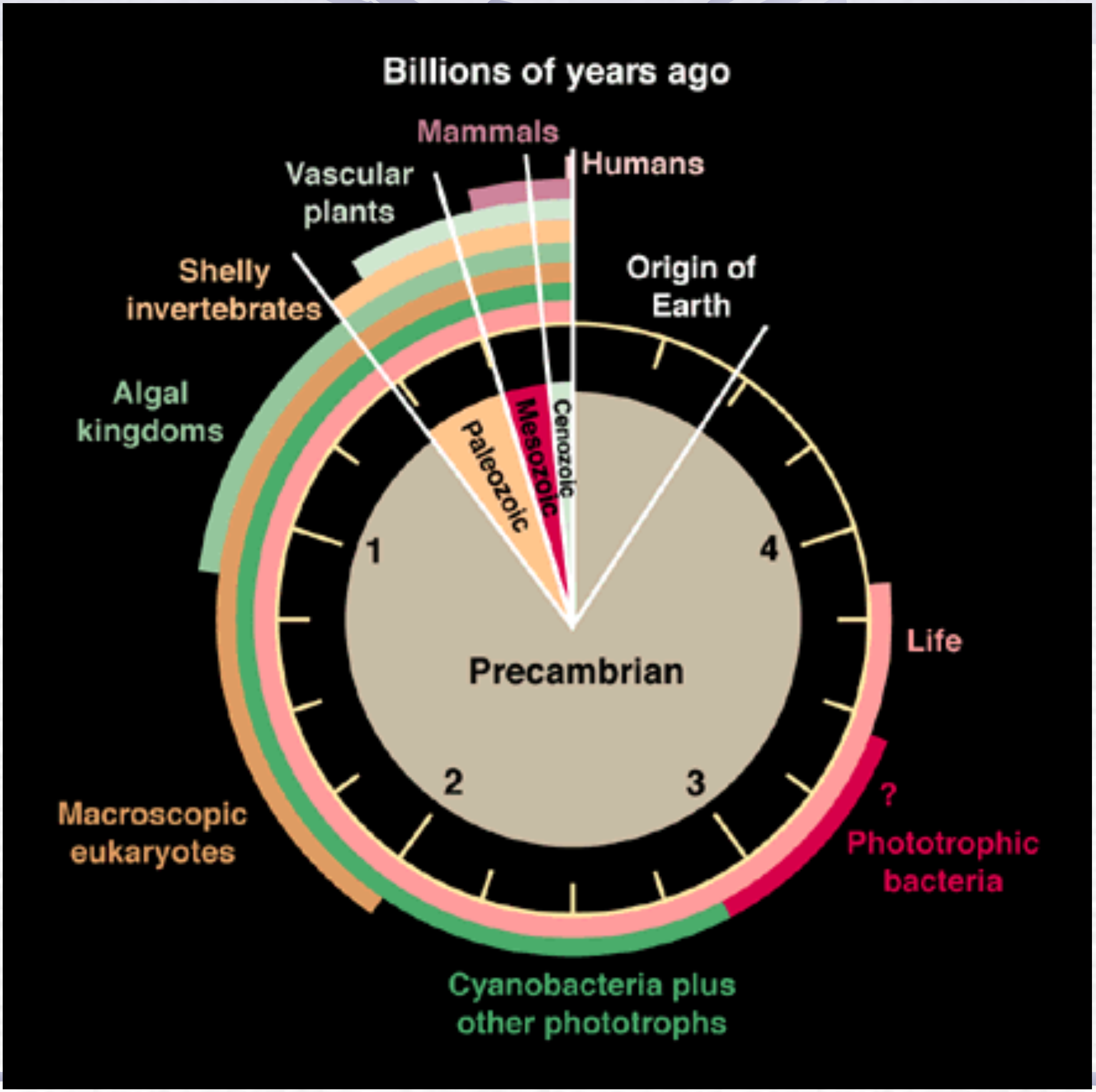

(*S*)-Carvone
(caraway)

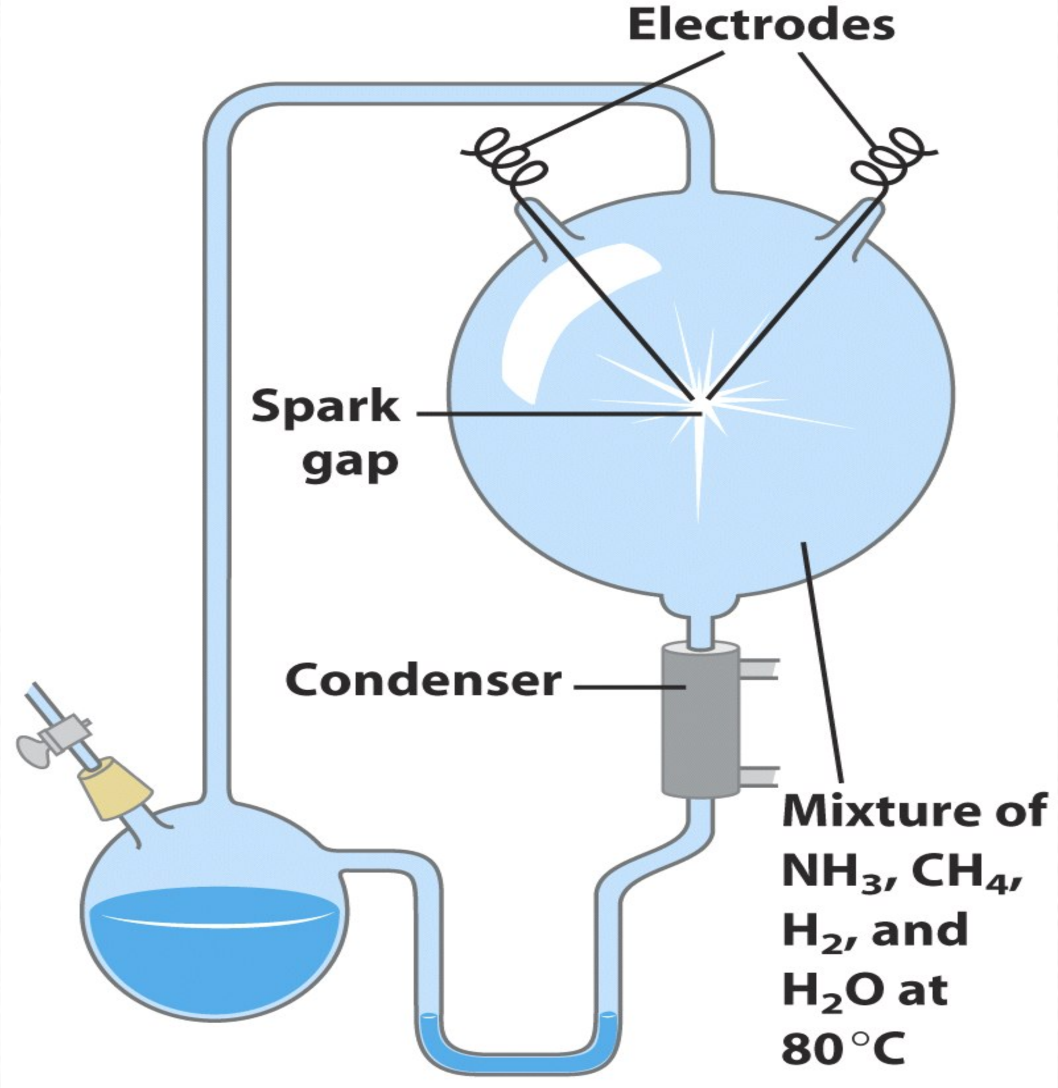


L-Aspartyl-L-phenylalanine methyl ester
(aspartame) (sweet)



L-Aspartyl-D-phenylalanine methyl ester
(bitter)


Billions of years ago
Mammals
Humans
Vascular plants
Shelly invertebrates
Origin of Earth
Algal kingdoms
Paleozoic
Mesozoic
Cenozoic
1
4
Precambrian
Life
2
3
Macroscopic eukaryotes
?
Phototrophic bacteria
Cyanobacteria plus other phototrophs



Electrodes
Spark gap
Condenser
Mixture of $NH_3$, $CH_4$, $H_2$, and $H_2O$ at 80 °C

table 3–6

**Some Products Formed under Prebiotic Conditions**

| **Carboxylic acids** | **Nucleic acid bases** | **Amino acids** | **Sugars** |
|---|---|---|---|
| Formic acid | Adenine | Glycine | Straight and branched pentoses and hexoses |
| Acetic acid | Guanine | Alanine | |
| Propionic acid | Xanthine | $\alpha$-Aminobutyric acid | |
| Straight and branched fatty acids ($C_4$–$C_{10}$) | Hypoxanthine | Valine | |
| Glycolic acid | Cytosine | Leucine | |
| Lactic acid | Uracil | Isoleucine | |
| Succinic acid | | Proline | |
| | | Aspartic acid | |
| | | Glutamic acid | |
| | | Serine | |
| | | Threonine | |

**Source:** From Miller, S.L. (1987) Which organic compounds could have occurred on the prebiotic earth? *Cold Spring Harb. Symp. Quant. Biol.* **52,** 17–27.

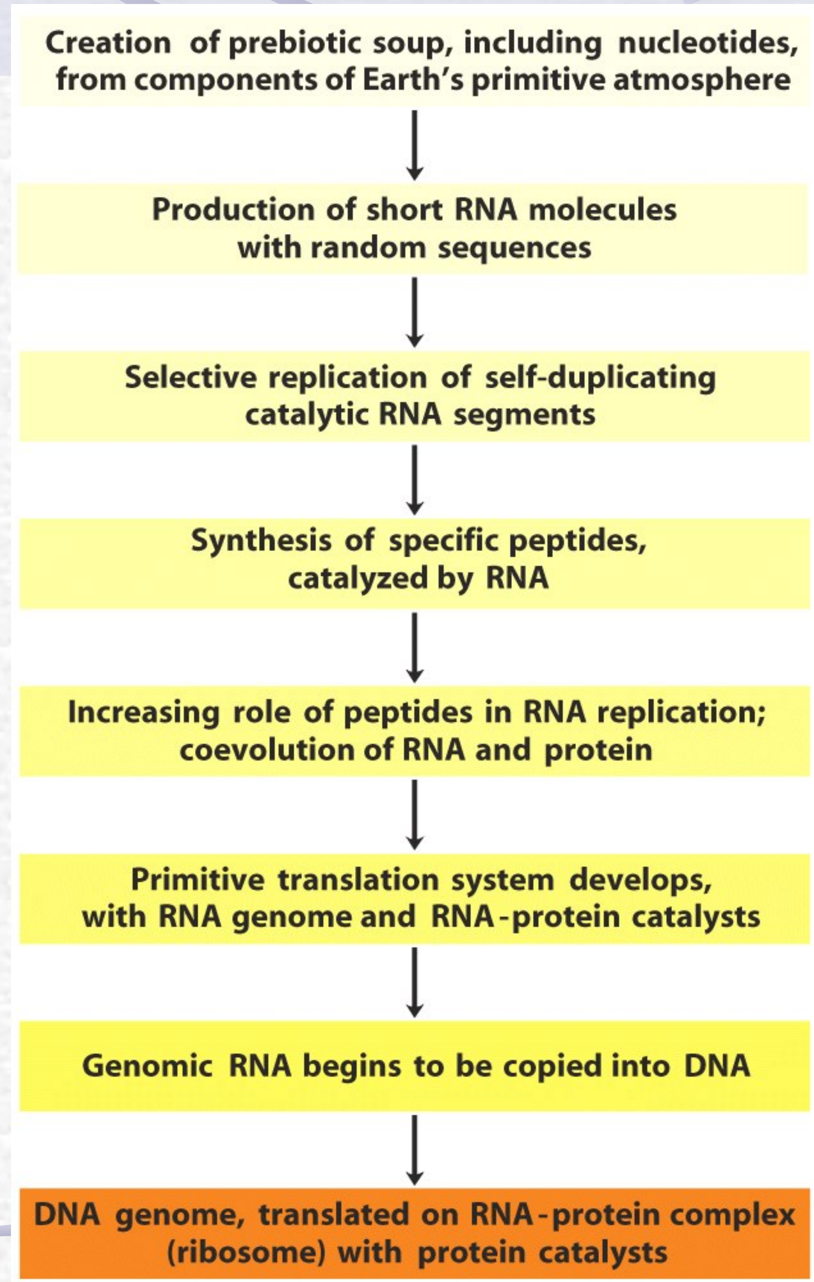

Creation of prebiotic soup, including nucleotides, from components of Earth's primitive atmosphere
Production of short RNA molecules with random sequences
Selective replication of self-duplicating catalytic RNA segments
Synthesis of specific peptides, catalyzed by RNA
Increasing role of peptides in RNA replication; coevolution of RNA and protein
Primitive translation system develops, with RNA genome and RNA-protein catalysts
Genomic RNA begins to be copied into DNA
DNA genome, translated on RNA-protein complex (ribosome) with protein catalysts

**TABLE 1–4 Some Organisms Whose Genomes Have Been Completely Sequenced**

| Organism | Genome size (millions of nucleotide pairs) | Biological interest |
|---|---|---|
| *Mycoplasma pneumoniae* | 0.8 | Causes pneumonia |
| *Treponema pallidum* | 1.1 | Causes syphilis |
| *Borrelia burgdorferi* | 1.3 | Causes Lyme disease |
| *Helicobacter pylori* | 1.7 | Causes gastric ulcers |
| *Methanococcus jannaschii* | 1.7 | Grows at 85 °C! |
| *Haemophilus influenzae* | 1.8 | Causes bacterial influenza |
| *Methanobacterium thermoautotrophicum* | 1.8 | Member of the Archaea |
| *Archaeoglobus fulgidus* | 2.2 | High-temperature methanogen |
| *Synechocystis* sp. | 3.6 | Cyanobacterium |
| *Bacillus subtilis* | 4.2 | Common soil bacterium |
| *Escherichia coli* | 4.6 | Some strains cause toxic shock syndrome |
| *Saccharomyces cerevisiae* | 12.1 | Unicellular eukaryote |
| *Plasmodium falciparum* | 23 | Causes human malaria |
| *Caenorhabditis elegans* | 97.1 | Multicellular roundworm |
| *Anopheles gambiae* | 278 | Malaria vector |
| *Mus musculus domesticus* | $2.5 \times 10^3$ | Laboratory mouse |
| *Homo sapiens* | $2.9 \times 10^3$ | Human |

# Introduction to "-omics"

Def. The term –omics represents the rigorous study of various collections of molecules, biological processes or physiological and structures such as systems, represented most prominently by genomics.

The human genome encodes over 30,000 genes and generates more than 100,000 functionally distinct proteins. Most genes have small sequence differences (polymorphisms) that occur between individuals at about every 1,500 base pairs. SNPs make up about 90% of all human genetic variability.

Allele – any one of a number of alternate forms of the same gene

Genotype – the genetic material in the chromosome

Phenotype – properties of an organism that are produced by interaction with the environment

# Genetic Variation and Dental Care JADA 140:896, 2009

Dental care – related anxiety, fear of dental pain and avoidance of dental care may be influenced by genetic variations.

An example is naturally red haired persons who have a melanocortin-1 receptor gene variant which causes them to be resistant to subcutaneous local anesthetics (ie tooth-numbing drugs like novocaine).

Consequently, these persons experience troublesome episodes during  dental procedures, develop a fear of dental care and avoid all future checkups.

(a possible solution is to use a relaxant such as valium during treatments)

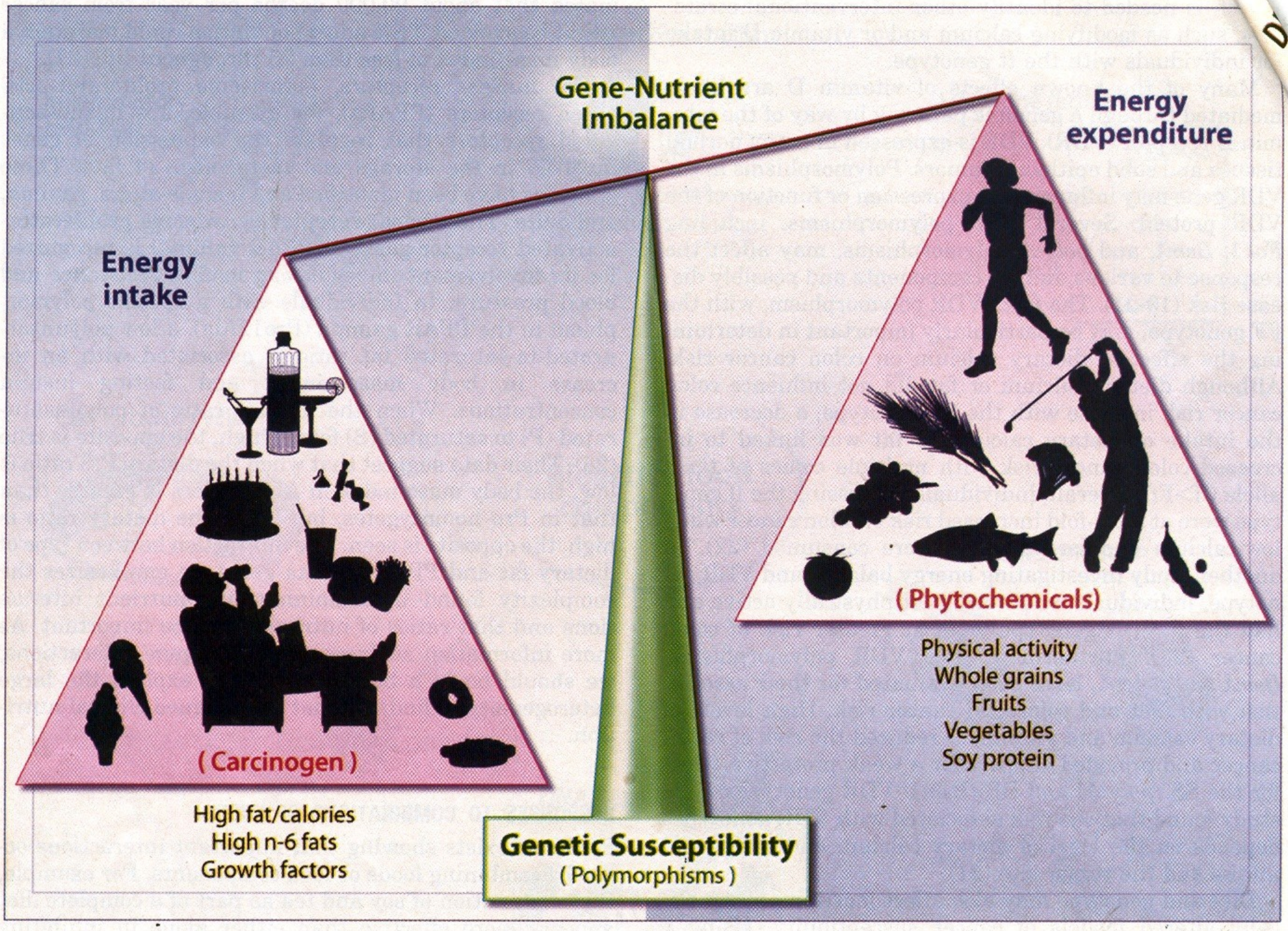
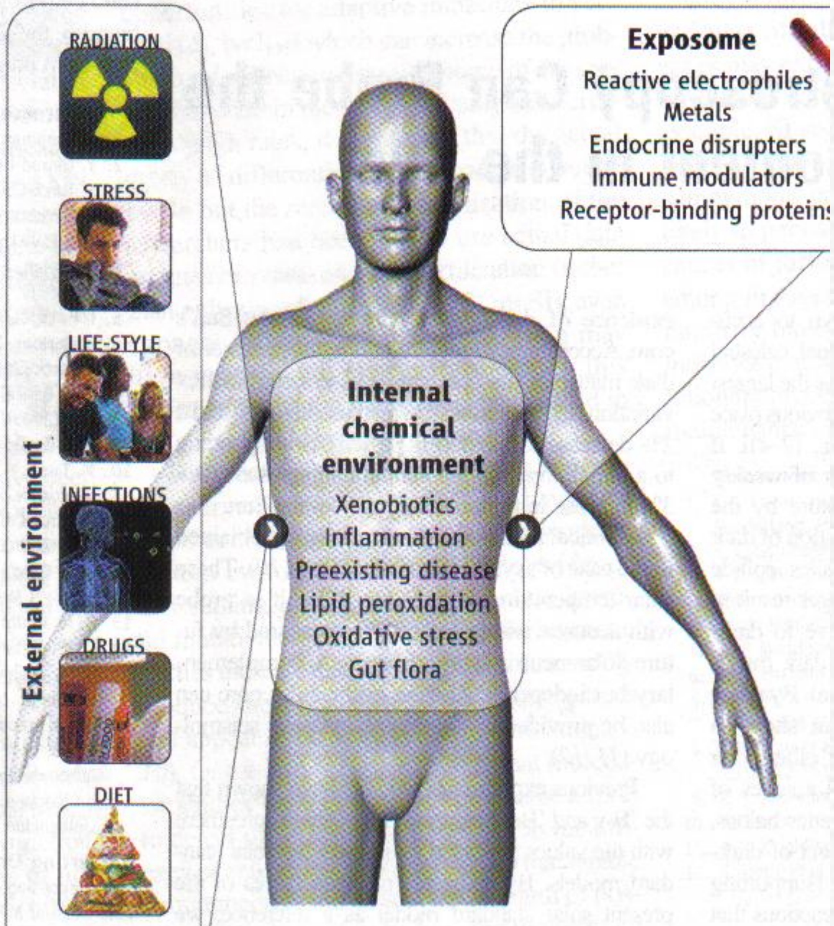
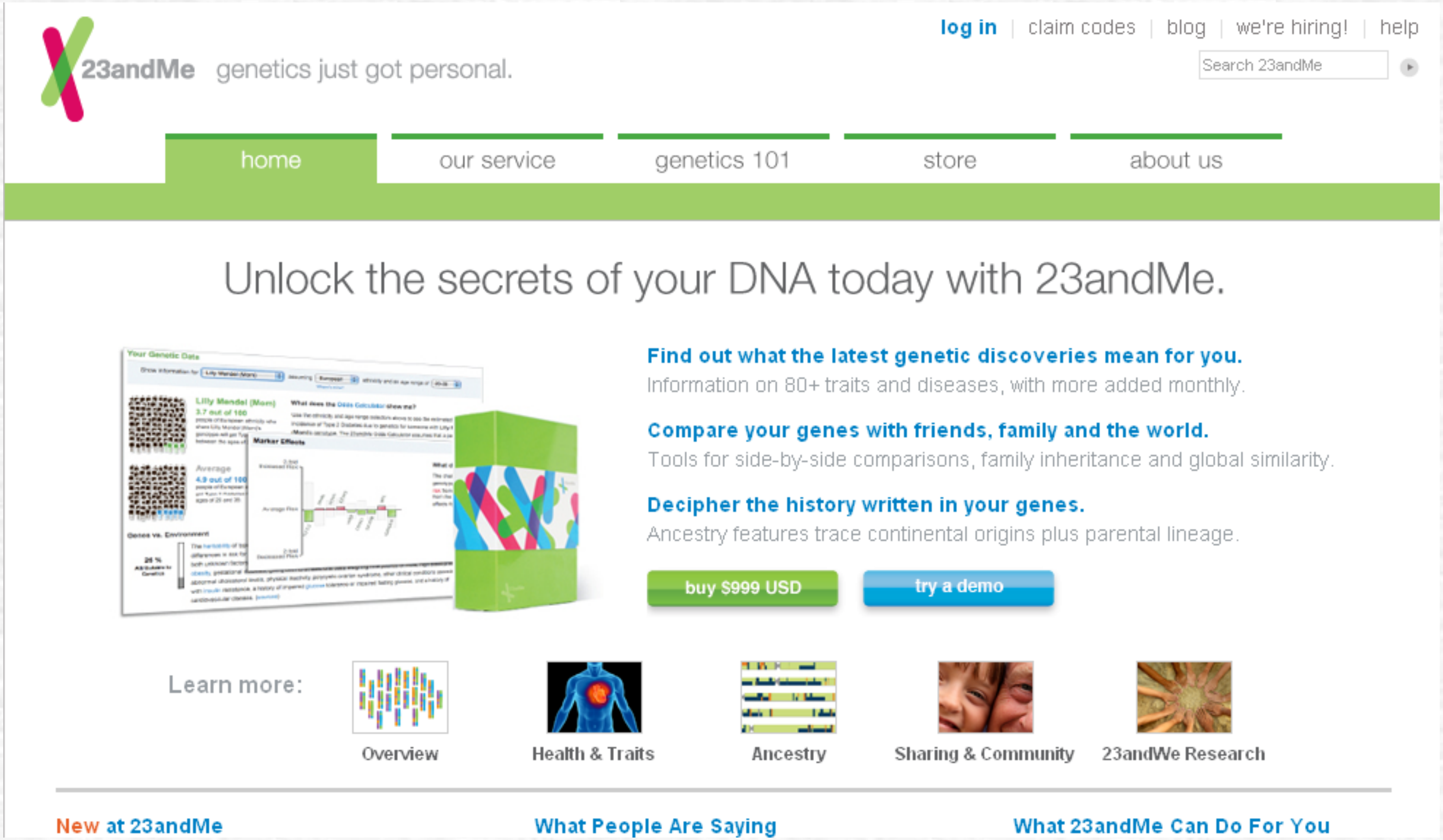



**Figure 4.** Certain genetic polymorphisms can shift the balance of energy intake and energy expenditure and thereby influence bioenergetics and obesity. Higher energy intakes, a low polyunsaturated-to-saturated fat ratio, insulin resistance, and a sedentary lifestyle leading to obesity are risk factors for chronic diseases, such as heart disease, diabetes, and cancer, depicted when the scale is sloping downward. The right side of the scale portrays lifestyle including physical activity and a diet rich in whole grains, fruits, vegetables, and soy protein, which are associated with less risk for obesity and chronic disease. Gene-nutrient imbalances may explain the morbidity and mortality associated with obesity.

70-90 % of risk for diseases is due to environmental exposures. The term EXPOSOME refers to the totality of environmental exposures from conception onward.




**Characterizing the exposome.** The exposome represents the combined exposures from all sources that reach the internal chemical environment. Toxicologically important classes of exposome chemicals are shown. Signatures and biomarkers can detect these agents in blood or serum.


23andMe
genetics just got personal.
log in | claim codes | blog | we're hiring! | help
Search 23andMe
home
our service
genetics 101
store
about us
Unlock the secrets of your DNA today with 23andMe.
Find out what the latest genetic discoveries mean for you.
Information on 80+ traits and diseases, with more added monthly.
Compare your genes with friends, family and the world.
Tools for side-by-side comparisons, family inheritance and global similarity.
Decipher the history written in your genes.
Ancestry features trace continental origins plus parental lineage.
buy $999 USD
try a demo
Learn more:
Overview
Health & Traits
Ancestry
Sharing & Community
23andWe Research
New at 23andMe
What People Are Saying
What 23andMe Can Do For You

# Genetic Tests Available

Abdominal aneurism
Alzheimers disease
Arterial fibrulation
Brain aneurism
Breast cancer
Celiac disease
Crohn's disease
Deep vein thrombosis
Diabetes type 2
Glaucoma
Graves' disease
Heart attack
Hemochromatosis
Lactose intolerance

Lung cancer
Lupus
Macular degeneration
Melanoma
Multiple sclerosis
Obesity
Osteoarthritis
Prostate cancer
Psoriasis
Restless leg syndrome
Rheumatoid arthritis
Sarcoidosis
Stomach cancer (diffuse)

Cost $500 (2009)

# Practice Exercises

CHAPTER 1

## A 1% solution of NaF equals how many ppm's?

a. 1
b. 10
c. 100
d. 1000
e. 10,000

1% = 1g/100 ml = 10g/L x 1000mg/g = 10,000mg/L

1 ppm = 1 mg/L so ans is 10,000 ppm (e)

1. A Eukaryotic cell is homogenized and centrifuged at 150,000 xg for 1 hour. The pellet will contain all of the following EXCEPT which one?

a. Organelles
b. Ribosomes
**c. Enzymes**
d. Mitochondria
e. Endoplasmic reticulum

2. The basic difference between prokaryotes and eukaryotes is:

- Presence of a nuclear envelope.
- Bacteria have a nucleid which has no membrane.
- Eukaryotes have a nucleus which has a double membrane.

3. Small cells have a (large, small) surface/volume ratio so $O_2$ diffusion is (easy, difficult).

- Small cells have a large surface/volume ratio so $O_2$ diffusion is easy.

- Large cells have a small surface/volume ratio so $O_2$ diffusion is difficult.

- Anabolic activity takes place in which of the following? (hint check ALL that are correct)

A. Cytosol
B. Lysosomes
C. Mitochondria
D. RER
E. SER

4. An example of a level 3 supramolecular complex is:

a. DNA
b. Cellulose
c. **Plasma membrane**
d. The cell
e. Nucleotide

5. The plasma membrane is a barrier to free passage of:

a. $Na^+$
b. $K^+$
c. Polar molecules
d. Charged molecules
e. **All of these**

6. Both plant and animal cells contain:

a. Thylakoid membrane
b. Central vacuole
c. Glyoxysomes
d. Chloroplasts
e. **Rough endoplasmic reticulum**

7. An element essential for life with the highest molecular weight is:

a. Chromium
b. Copper
c. **Iodine**
d. Iron
e. Selenium

8. Which of the following is characterized as an essential trace element?

a. Aluminum
b. Chlorine
c. Hydrogen
**d. Magnesium**
e. Sodium

9. For a chiral carbon atom which substrate has (a) the highest, (b) the lowest priority?

a. -NH

b. -CHO

c. $CH_2OH$

**d. -OH (highest)**

**e. $-CH_3$ (lowest)**

10. The primitive atmosphere of earth contained all the following gases, EXCEPT which one?

a. $H_2O$

**b. $O_2$**

c. $NH_3$

d. $CH_4$

e. $H_2$

11. Genome sequences have been obtained for all the following species, EXCEPT which one?

a. Fruit fly
b. Roundworm
c. Rice
d. Mouse
e. **All of these have been sequenced**