

?

College is a place where a professor's lecture notes go straight to the students' lecture notes, without passing through the brains of either.

Edwin Emery Slosson

COURSE CONTENT:

- Introduction to the Cell. Life on Earth. Evolution.
- Internal Organization of the Cell. Membrane.

LIVING THINGS

- organized chemical factories;
- take in matter from their surroundings - to create and maintain its organization;
- generate copies of themselves;

- HEREDITY - reproduces itself, yields progeny that belong to the same species: the parent organism hands down information specifying the characteristics that the offspring shall have.

LIVING THINGS

- **ARE MADE OF CELLS - share the same machinery for their most basic functions;**
- **CELL - unit of living matter.**
- **COMPLEX SYSTEM OF CHEMICAL PROCESSES that use FREE ENERGY.**

LIFE on EARTH

- unity in diversity -

"United in diversity" – the motto of the EU (2000).

CONCEPT of unity in diversity - "unity without uniformity and diversity without fragmentation"

- indigenous peoples in North America and Taoist societies in 400-500 B.C.

LIFE on EARTH

Unity – constancy in fundamental mechanisms

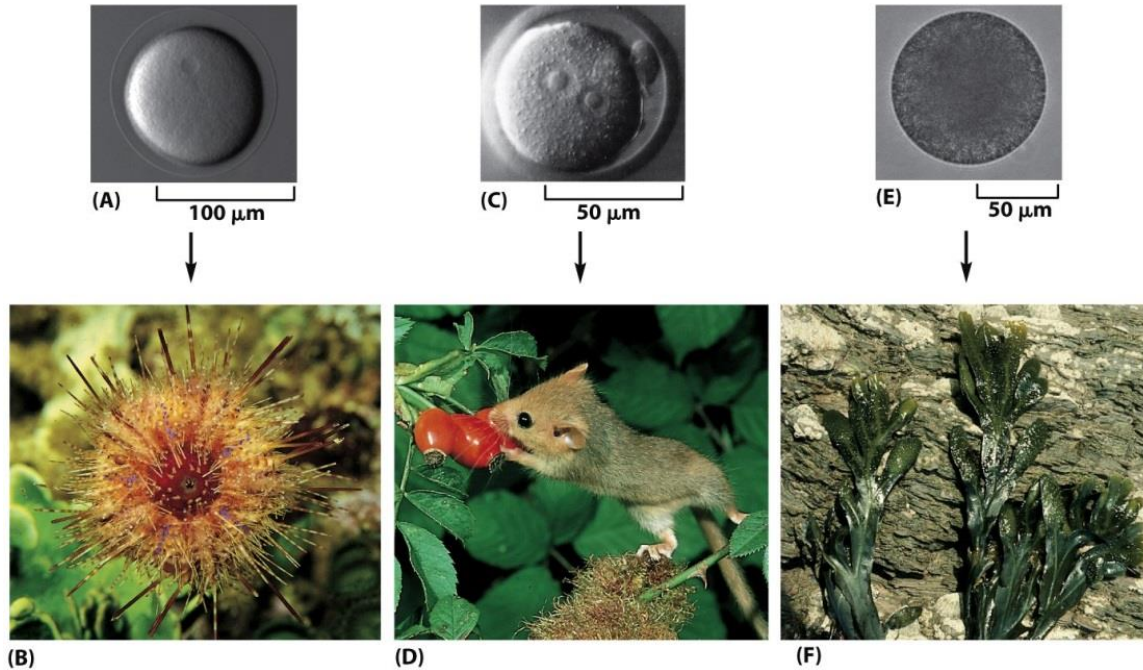
Diversity – variety in individual particulars

DIVERSITY

- more than 10 million—perhaps 100 million—
living species on Earth today.
- living organisms:
 - most are single cells;
 - multicellular linked by intricate systems of
communication.

DIVERSITY

Intra- and interspecies differences



Cells - vehicles for the hereditary information

-gather raw materials and construct a new cell
in its own image, with a new copy of the
hereditary information.

DIVERSITY

Intra- and interspecies differences

human body - 3.72×10^{13} cells (Bianconi et al., 2013)

- 200 cell types that qualify for individual names

1 Cells that are derived primarily from endoderm

- 1.1 Exocrine secretory epithelial cells
- 1.2 Hormone secreting cells

2 Derived primarily from ectoderm

- 2.1 Integumentary system
 - 2.1.1 Keratinizing epithelial cells
 - 2.1.2 Wet stratified barrier epithelial cells
- 2.2 Nervous system
 - 2.2.1 Sensory transducer cells
 - 2.2.2 Autonomic neuron cells
 - 2.2.3 Sense organ and peripheral neuron supporting cells
 - 2.2.4 Central nervous system neurons and glial cells
 - 2.2.5 Lens cells

3 Derived primarily from mesoderm

- 3.1 Metabolism and storage cells
- 3.2 Barrier function cells (lung, gut, exocrine glands and urogenital tract)
 - 3.2.1 Kidney
- 3.3 Extracellular matrix cells
- 3.4 Contractile cells
- 3.5 Blood and immune system cells
- 3.6 Germ cells
- 3.7 Nurse cells
- 3.8 Interstitial cells

DEFINITIONS

CELL BIOLOGY

- scientific discipline that studies CELLS – their physiological properties, their structure, the organelles they contain, interactions with their environment, their life cycle, division and death.
- mechanisms of biological phenomena at the cellular level

MOLECULAR BIOLOGY

- the branch of biology that deals with the MOLECULAR BASIS OF BIOLOGICAL ACTIVITY.
- overlaps with other areas of biology and chemistry, particularly genetics and biochemistry.
- interactions between the various systems of a cell: types of DNA, RNA and protein biosynthesis.

The Origin and Evolution of Eukaryotic Cells

Fossils of the first eukaryotic cells appear in rocks 1.5 billion years ago, over 2 billion years after bacteria.

Characteristic	Prokaryote	Eukaryote
Nucleus	Absent	Present
Diameter of a typical cell	$\approx 1 \mu\text{m}$	10–100 μm
Cytoskeleton	Absent	Present
Cytoplasmic organelles	Absent	Present
DNA content (base pairs)	1×10^6 to 5×10^6	1.5×10^7 to 5×10^9
Chromosomes	Single circular DNA molecule	Multiple linear DNA molecules

Creation vs. Evolution debate

Atom => Molecule => Cell => Organism;

■ Theories on the Origin of Life ⇔ Cell:

- Creationism;

- Evolutionism;

...Charles Darwin (February 12th 1809 – 19th April 1882)

...155 years *On the Origin of Species* (24th November 1859)

Creationism

Old Testament- Genesis – ? - 1445 BC (?Moses)

The first day (EARTH) - In the beginning God created the heaven and the earth... And God said, Let there be light...

The third day (PLANTS) - And the earth brought forth **grass**, herbs yielding seed after their kind, and trees bearing fruit...

The Fifth Day (FISH and BIRDS) - And God said, Let the **waters swarm with swarms of living creatures**, and let **birds fly above the earth** in the open firmament of heaven....

The Sixth Day (CREATURES on LAND) - ... And God said, Let us make **MAN** in our image, after our likeness: and let them have dominion over the fish of the sea...

watchmaker analogy (watchmaker argument)



PRO & CON

- arguments for the existence of God and for the intelligent design of the universe.
- general premise: you can tell, simply by looking at something, whether or not it was the product of intelligent design.

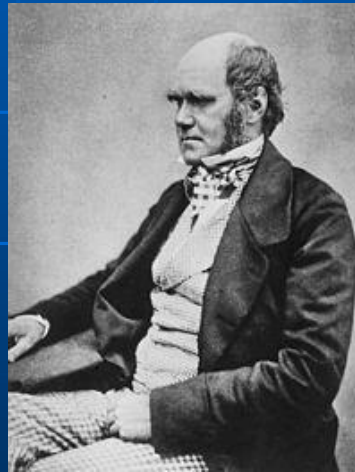
PLAN, PROJECT



Natural Theology, or Evidences of the Existence and Attributes of the Deity collected from the Appearances of Nature.

William Paley 1802

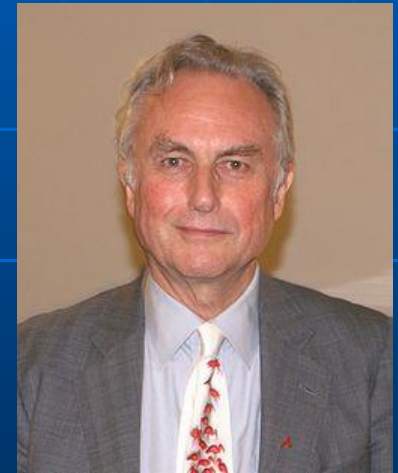
ADAPTATION



On the Origin of Species by Means of Natural Selection, or the Preservation of Favoured Races in the Struggle for Life.

Charles Darwin, 24 November 1859

EVOLUTION - ADAPTATION



The Blind Watchmaker: Why the Evidence of Evolution Reveals a Universe without Design.

Richard Dawkins, 1986

TYPE OF SELECTION:
natural, artificial, sexual and kin

Natural selection

DARWIN ONLINE

Publications Manuscripts Biography Media About us Search [Advanced search](#)

The world's largest and most widely used resource on Charles Darwin. On [Facebook](#).

- **Darwin's Complete Publications**

[Books](#) (*Origin of Species, Descent of Man, Voyage of the Beagle...*)

[Articles](#) (*Darwin & Wallace paper...*)

[Published Letters](#) (*Darwin and Henslow...*)

[Published Manuscripts](#) (*Autobiography, Beagle diary- audio...*)

- **International Darwin Bibliography** (Freeman database)

- **Darwin's Private Papers & Manuscripts**

[Notebooks](#), [marriage notes](#), [Journal](#)
[Geological diary](#), [Emma's diaries](#), [Annie Darwin...](#)

- **Darwin Manuscript Catalogue** (database)

- **Supplementary Works** (by other authors)

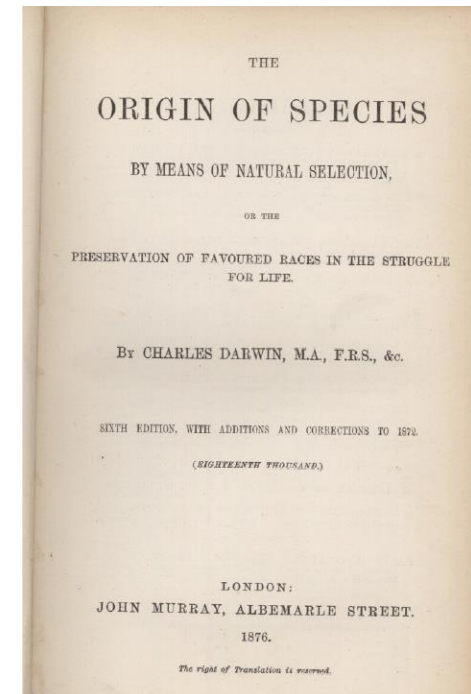
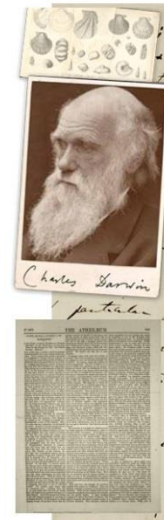
[Reviews & Responses](#)

[Darwin's *Beagle* specimens](#)

[Obituaries & Recollections](#)

[Works about Darwin](#) (*Companion, Beagle itinerary...*)

Forthcoming: [editions](#), [translations](#), [introductions](#), [manuscripts](#) & much more. See [What's new](#)



<http://darwin-online.org.uk/>

Natural selection - Evolutionism

- works on individuals within a population
- => a variation that provides benefit to the individual will become more prevalent in the population.
- "random mutation" followed by natural selection;
- fossil evidence and mitochondrial sequence data have indicated a recent divergence of PBs from within brown bears (aprox. 150Kya)



Brown bears (*Ursus arctos*) and Polar bears (PBs; *Ursus maritimus*)

Type of selection: natural, artificial, sexual and kin.

- 1993 *The Red Queen: Sex and the Evolution of Human Nature.*

A “Red Queen theory” for the evolution of sexual reproduction.

- 1996 *The Origins of Virtue: Human Instincts and the Evolution of Cooperation*

- 1999 *Genome: The Autobiography of a Species in 23 Chapters*

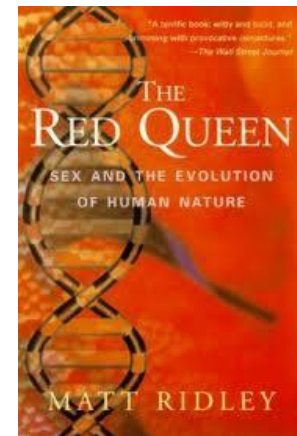
- 2003 *Nature via Nurture: Genes, Experience, & What Makes Us Human,*

also later released under the title *The Agile Gene: How Nature Turns on Nurture* in 2004

- 2006 Francis Crick: Discoverer of the Genetic Code

- 2010 *The Rational Optimist: How Prosperity Evolves.*

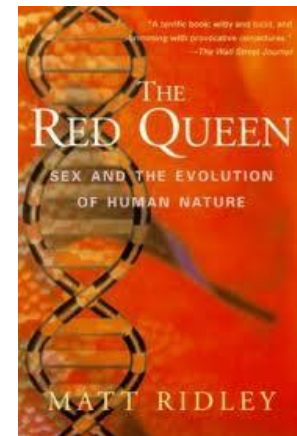
Reviewed in Nature 465, 294–295 (20 May 2010).



SEXUAL SELECTION

- 1993 *The Red Queen: Sex and the Evolution of Human Nature*.
A “*Red Queen theory*” for the evolution of sexual reproduction.

Referring to Lewis Carroll's Red Queen from *Through the Looking-Glass*, a character who has to keep running to stay in the same place, Matt Ridley demonstrates why sex is humanity's best strategy for outwitting its constantly mutating internal predators.




Richard Dawkins

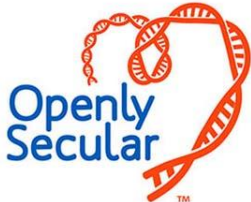
Log In Home | RDFS UK | Spanish | German | Website FAQ | Contact Us

Richard Dawkins Foundation for Reason & Science

About News Community Events Videos Openly Secular Store Get Involved Donate



Opening Minds, Changing Hearts™



Openly Secular


We are raising awareness about discrimination against the nonreligious and nonbeliever community by lifting their stories out of the shadows and into the mainstream. Please share your experience to help shed light on this problem and the need for acceptance and respect for the nonreligious and nonbelievers

Share your story

Featured




Good Wife Recap: Where There's a Will

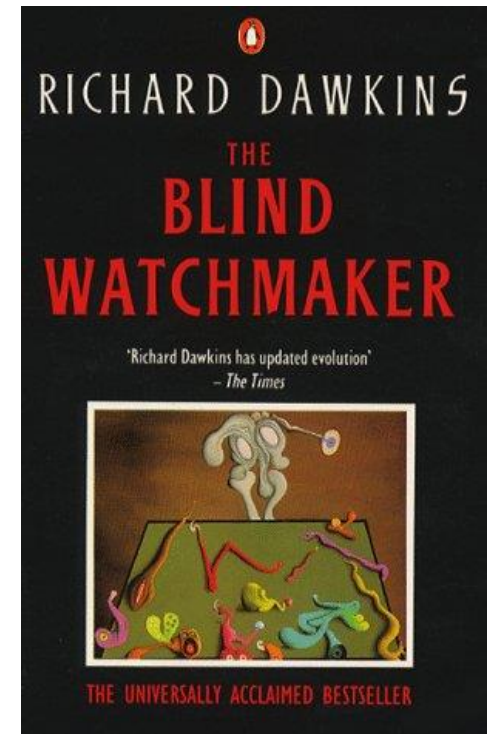


the QUESTION of the week

Question of the Week: March 11, 2015



The Steady Rise of The Nonreligious



<http://richarddawkins.net/>

Richard Dawkins

Selected publications [\[edit\]](#)

Main article: List of publications by Richard Dawkins

- Richard Dawkins (1976). *The Selfish Gene*. Oxford: Oxford University Press. ISBN 0-19-286092-5.
- Richard Dawkins (1982). *The Extended Phenotype*. Oxford: Oxford University Press. ISBN 0-19-288051-9.
- Richard Dawkins (1986). *The Blind Watchmaker*. New York: W. W. Norton & Company. ISBN 0-393-31570-3.
- Richard Dawkins (1995). *River Out of Eden*. New York: Basic Books. ISBN 0-465-06990-8.
- Richard Dawkins (1996). *Climbing Mount Improbable*. New York: W. W. Norton & Company. ISBN 0-393-31682-3.
- Richard Dawkins (1998). *Unweaving the Rainbow*. Boston: Houghton Mifflin. ISBN 0-618-05673-4.
- Richard Dawkins (2003). *A Devil's Chaplain*. Boston: Houghton Mifflin. ISBN 0-618-33540-4.
- Richard Dawkins (2004). *The Ancestor's Tale*. Boston: Houghton Mifflin. ISBN 0-618-00583-8.
- Richard Dawkins (2006). *The God Delusion*. Boston: Houghton Mifflin. ISBN 0-618-68000-4.
- Richard Dawkins (2009). *The Greatest Show on Earth: The Evidence for Evolution*. Free Press (United States), Transworld (United Kingdom and Commonwealth). ISBN 0-593-06173-X.
- Richard Dawkins (2011). *The Magic of Reality: How We Know What's Really True*. Free Press (United States), Bantam Press (United Kingdom). ISBN 978-1-4391-9281-8. OCLC 709673132 [↗](#).^[142]
- Richard Dawkins (2013). *An Appetite for Wonder: The Making of a Scientist*. Ecco Press (United Kingdom and United States). ISBN 978-0-06-228715-1.

“God Exists Because I Don’t Understand Science.”

Richard Dawkins

Documentary films [\[edit\]](#)

- *Nice Guys Finish First* (1986)
- *The Blind Watchmaker* (1987)^[143]
- *Growing Up in the Universe* (1991)
- *Break the Science Barrier* (1996)
- *The Root of All Evil?* (2006)
- *The Enemies of Reason* (2007)
- *The Genius of Charles Darwin* (2008)
- *Expelled: No Intelligence Allowed* (2008) – as himself
- *The Purpose of Purpose* (2009) – Lecture tour among American universities
- *Faith School Menace?* (2010)
- *Beautiful Minds* (April 2012) – BBC4 documentary
- *Sex, Death and the Meaning of Life* (2012)^[144]
- *The Unbelievers* (2013)

Other appearances [\[edit\]](#)


- *Doctor Who*: "The Stolen Earth" (2008) – as himself
- *The Simpsons*: "Black Eyed, Please" – appears in Ned Flanders' dream of Hell; provided voice as a demon version of himself^[145]

TREE OF LIFE

PEABODY MUSEUM
OF NATURAL HISTORY
YALE UNIVERSITY

Travels in the Great Tree of Life

HOME
LEARN ABOUT THE TREE OF LIFE!
ELEPHANT SHREWS
FILMS
A TREE OF LIFE ADVENTURE GAME!
MORPHING ARACHNIDS
FURTHER RESOURCES
CREDITS



"The affinities of all the beings of the same class have sometimes been represented by a **great tree**. I believe this simile largely speaks the truth."
- Charles Darwin, 1859

Welcome to the Tree of Life!

All living things - from the smallest microorganism to the largest vertebrate and redwood tree - are genetically related.

This genetic relatedness is expressed as an immense evolutionary "Tree of Life," or phylogeny, which provides the framework for our modern understanding of biology.

Travels in the Great Tree of Life is a new, family-friendly, multimedia exhibition that explores how we understand the complex relationships that link all living organisms.

Click the buttons on the left or the "Next Section" button to find out more!

NEXT SECTION ►

<http://archive.peabody.yale.edu/exhibits/treeoflife/>

TREE OF LIFE

PEABODY MUSEUM
OF NATURAL HISTORY
YALE UNIVERSITY

Travels in the Great Tree of Life

HOME

LEARN ABOUT THE TREE OF LIFE!

- What is the Tree of Life?
- What is a Phylogenetic Relationship?
- Evolution Along the Branches
- Extreme Divergence!
- Convergent Evolution
- Convergent Insect Eaters
- A Succulent Convergence
- Big Surprises
- Elephant Shrews
- Afrotheria
- Rafflesia
- A Monumental Scientific Challenge
- Computational Complexity
- Why Study the Tree of Life?
- Phylogenetic Predictions

ELEPHANT SHREWS

FILMS

A TREE OF LIFE ADVENTURE GAME!

MORPHING ARACHNIDS

FURTHER RESOURCES

CREDITS

Learn about the Tree of Life!

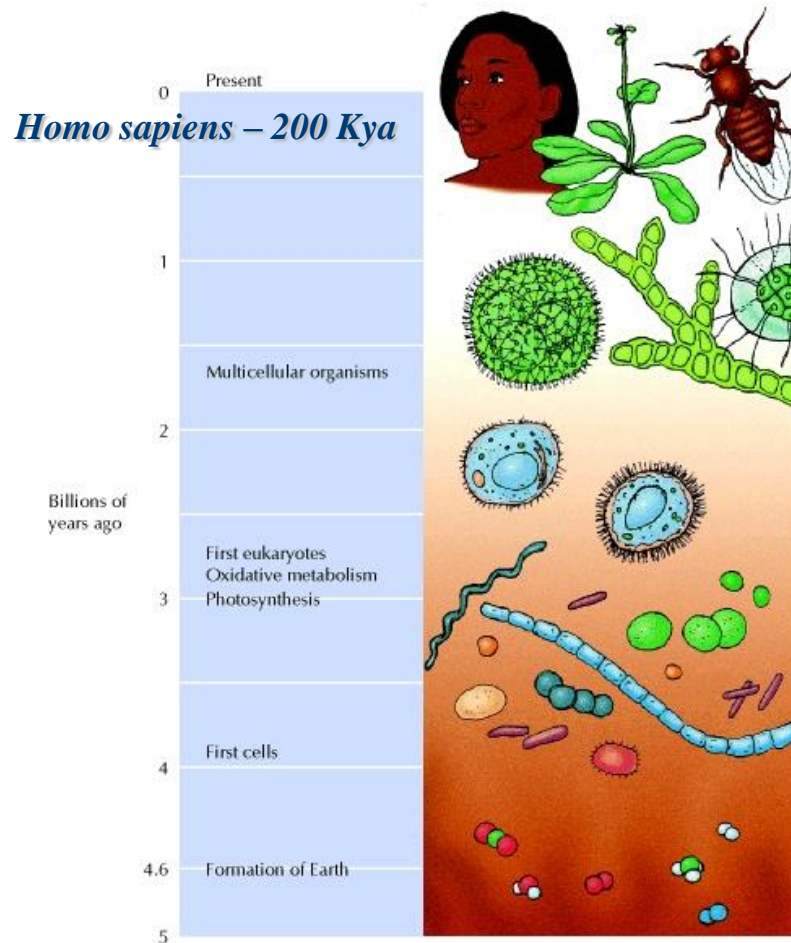
Pick a topic to learn about, or press the "Next Section" button below to go in order:

- [What is the Tree of Life?](#)
- [What is a Phylogenetic Relationship?](#)
- [Evolution Along the Branches](#)
- [Extreme Divergence!](#)
- [Convergent Evolution](#)
 - [Convergent Insect Eaters](#)
 - [A Succulent Convergence](#)
- [Big Surprises in the Tree of Life](#)
 - [Elephant Shrews](#)
 - [Afrotheria - Elephants, Elephant Shrews, and More!](#)
 - [Rafflesia - The World's Largest Flower](#)
- [A Monumental Scientific Challenge](#)
- [Computational Complexity](#)
- [Why Study the Tree of Life?](#)
- [Phylogenetic Predictions](#)

<http://archive.peabody.yale.edu/exhibits/treeoflife/>

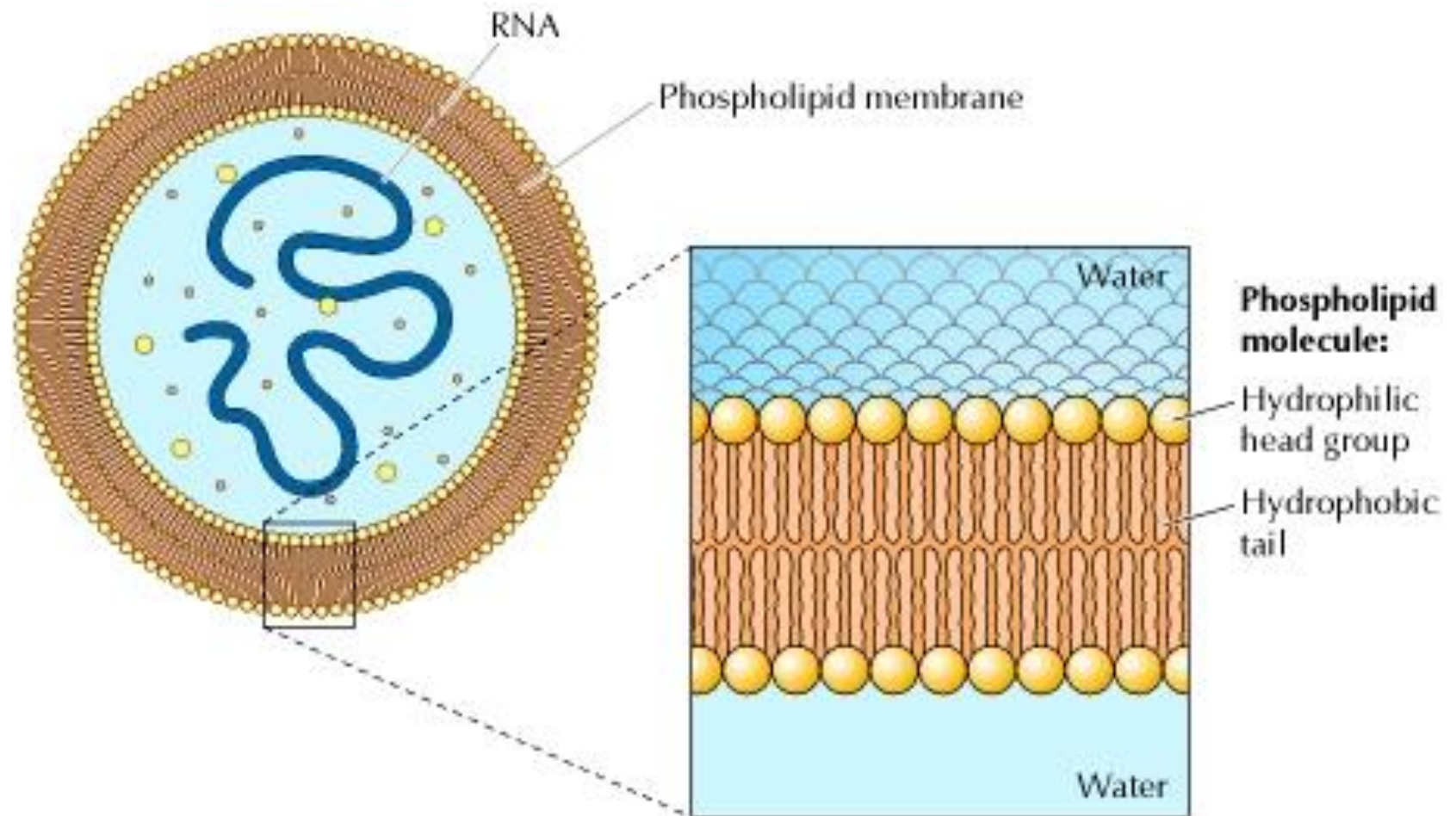
Time scale of evolution

Organic molecules \longrightarrow Cell



Prebiotic Chemistry on the Primitive Earth

1. the first auto-replicant molecules to appear seems to have been RNA;
 2. RNA-directed protein synthesis;
 3. The enclosure of self-replicating RNA and associated molecules in a phospholipid membrane;
- \Rightarrow FUNCTIONAL UNIT

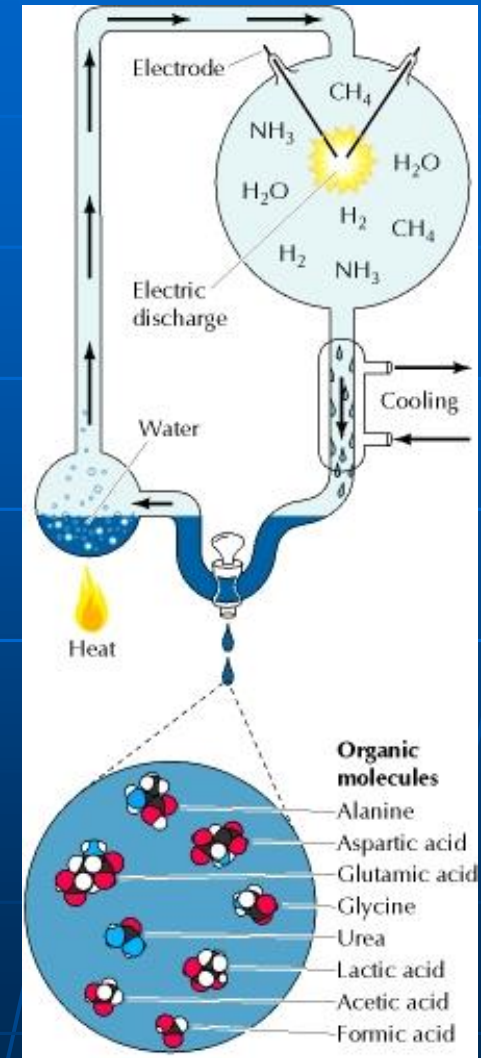


SPONTANEOUS FORMATION OF ORGANIC MOLECULES

The Scientific Method:

Hypothesis to Theory -> Experiment:

- first demonstrated experimentally (Stanley Miller, 1950s): the discharge of electric sparks into a mixture of H_2 , CH_4 , and NH_3 , in the presence of water, led to the formation of a variety of organic molecules, including several amino acids .



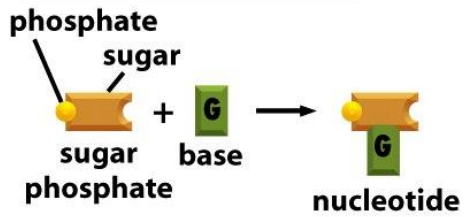
All Cells Store Their Hereditary Information in the Same Linear Chemical Code (DNA)

All living cells on Earth store their hereditary information in the form of double-stranded molecules of DNA—long unbranched paired polymer chains, formed always of the same four types of monomers—A, T, C, G.

These monomers are strung together in a long linear sequence that encodes the genetic information.

All Cells Store Their Hereditary Information in the Same Linear Chemical Code (DNA)

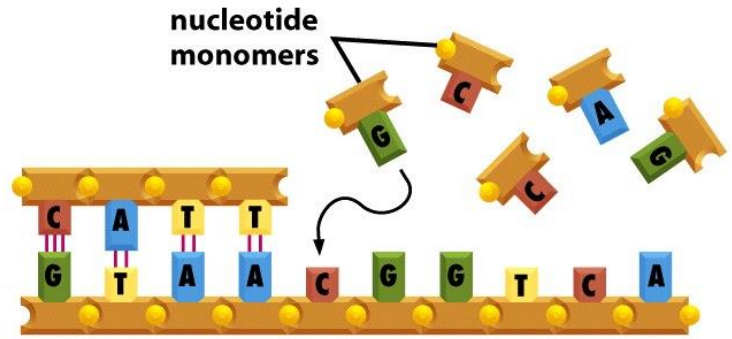
(A) building block of DNA



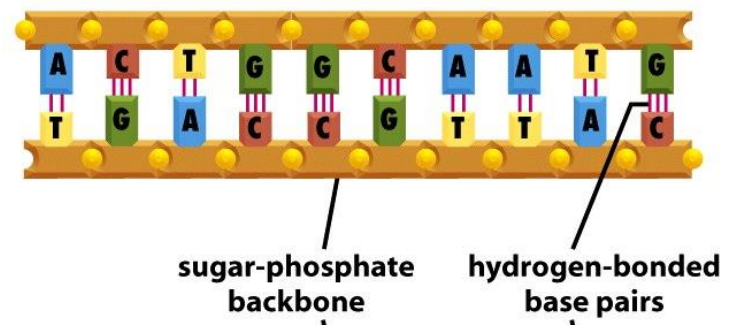
(B) DNA strand



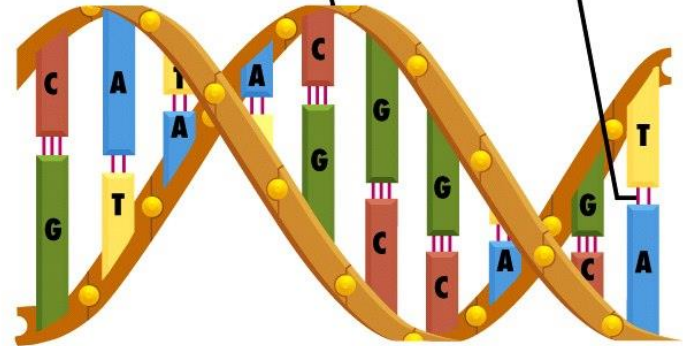
(C) templated polymerization of new strand



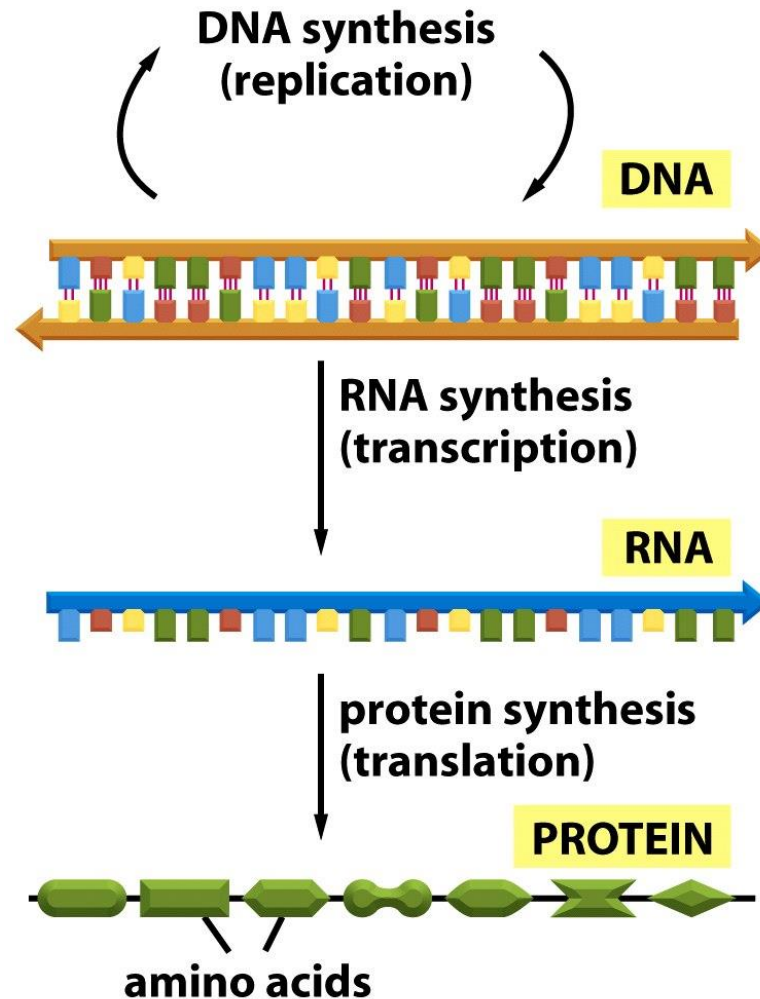
(D) double-stranded DNA



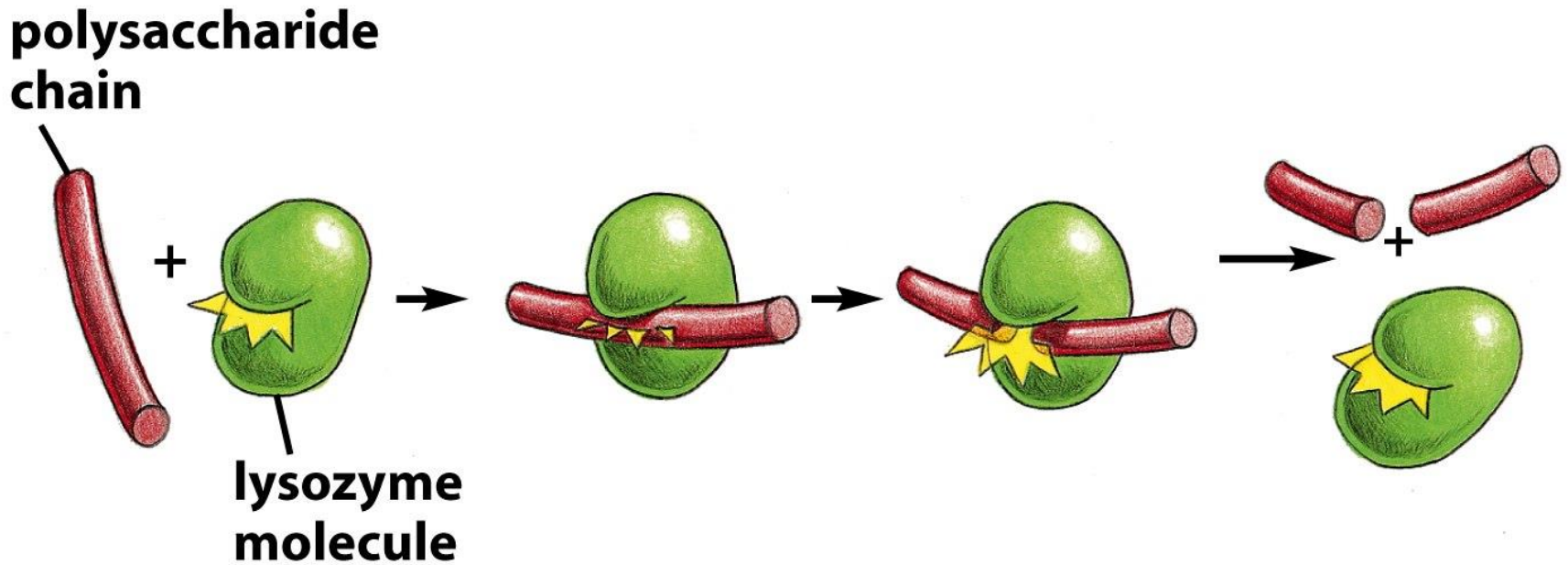
(E) DNA double helix



All Cells Transcribe Portions of Their Hereditary Information into the Same Intermediary Form (RNA)



All Cells Use Proteins as Catalysts



**All Cells Translate RNA
into Protein in the Same Way**

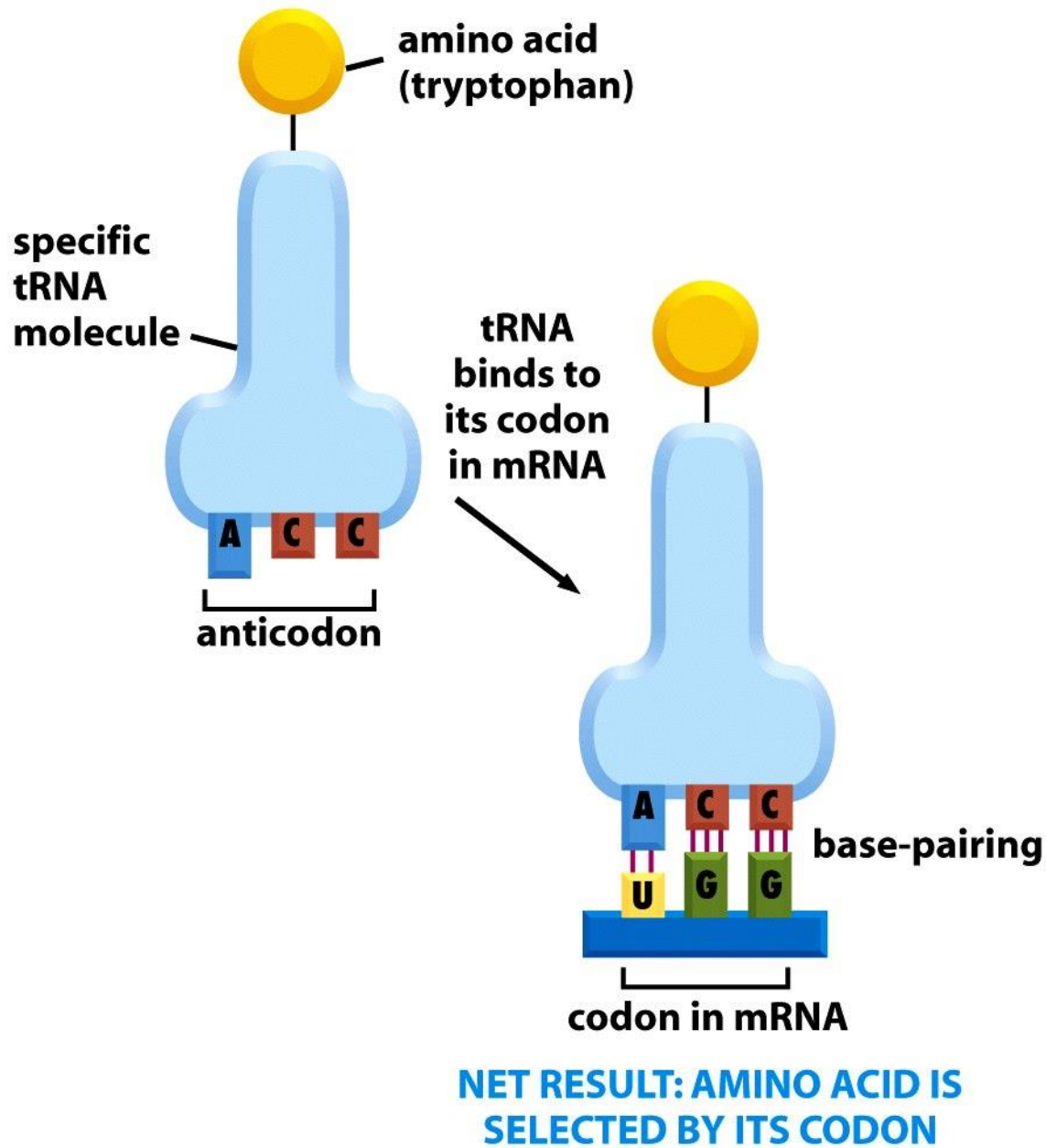
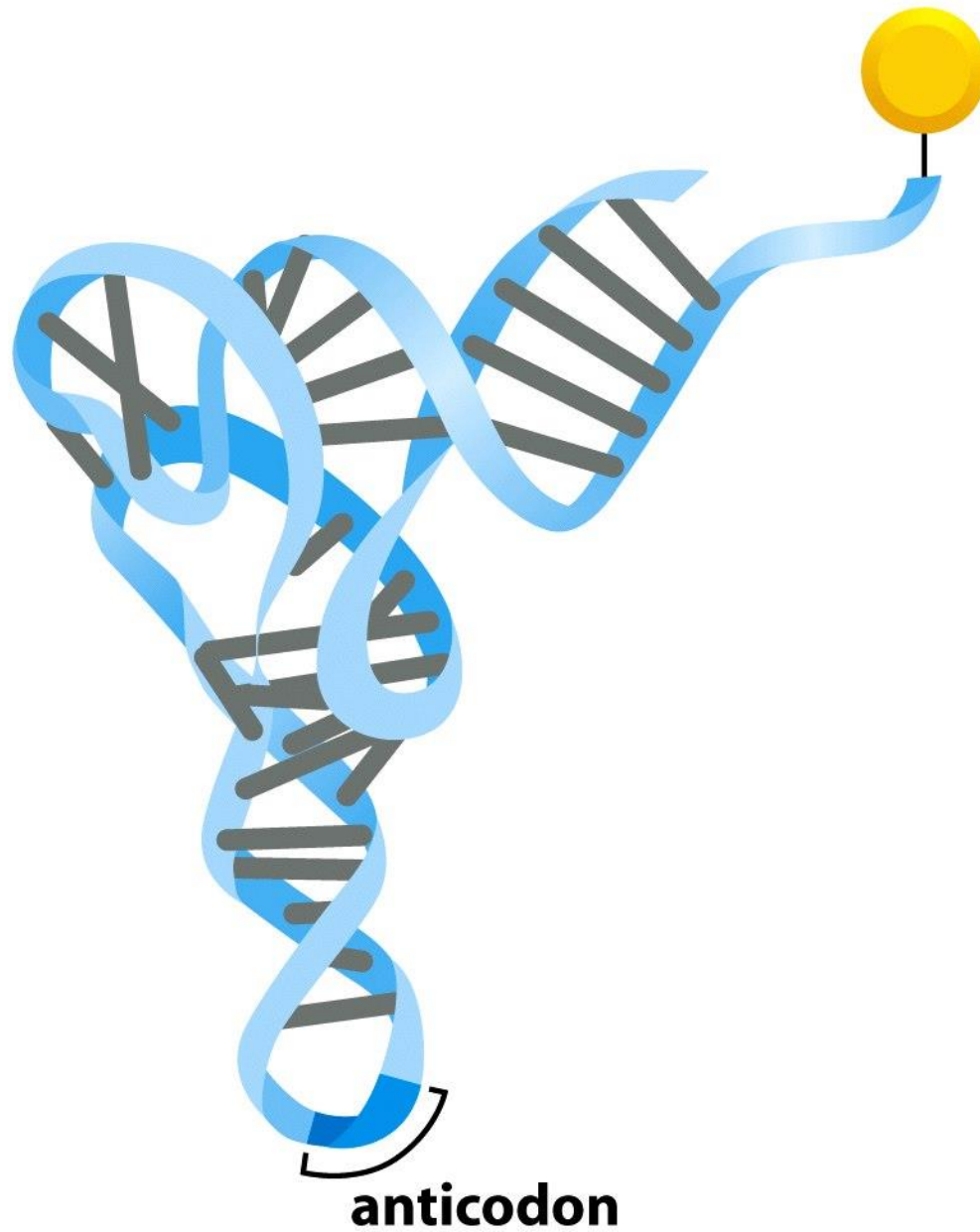


Figure 1-9a *Molecular Biology of the Cell*, Fifth Edition (© Garland Science 2008)



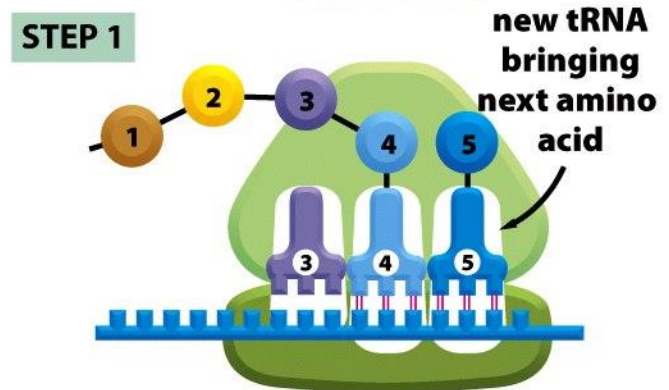
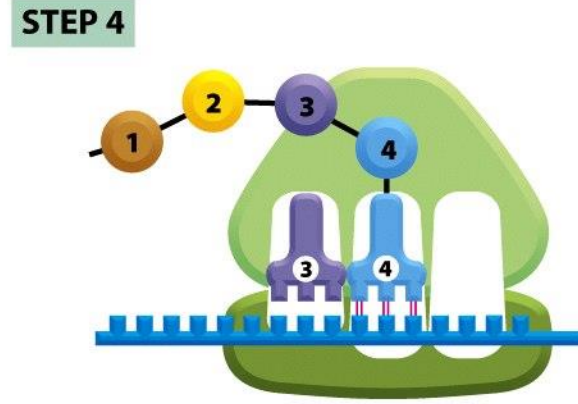
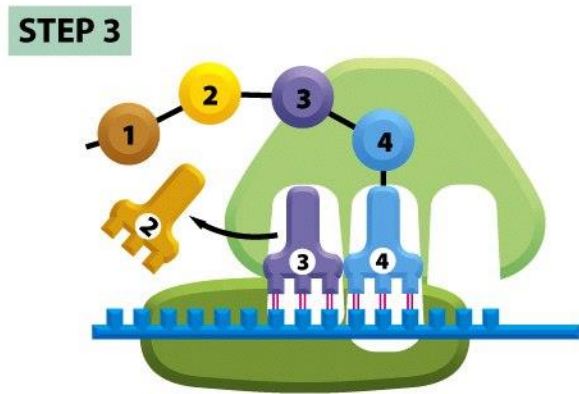
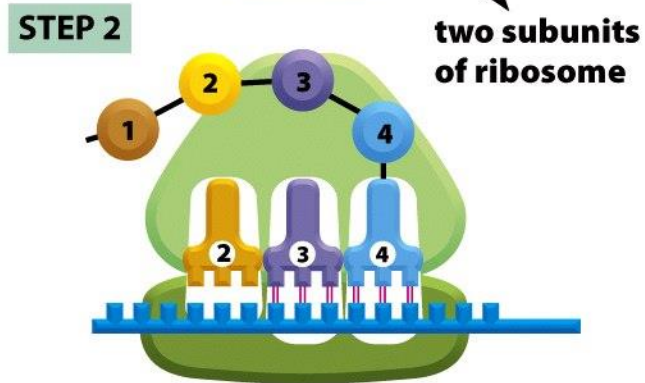
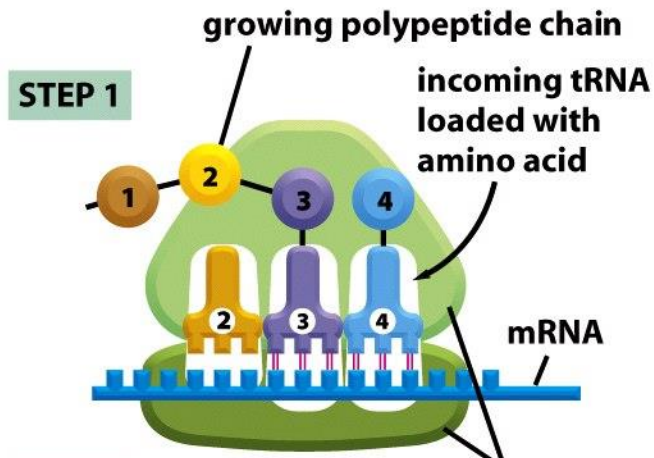


Figure 1-10a *Molecular Biology of the Cell*, Fifth Edition (© Garland Science 2008)

one **GENE** - fragment of genetic information
corresponding to one **PROTEIN**



A Living Cell Can Exist with Fewer Than 500 Genes

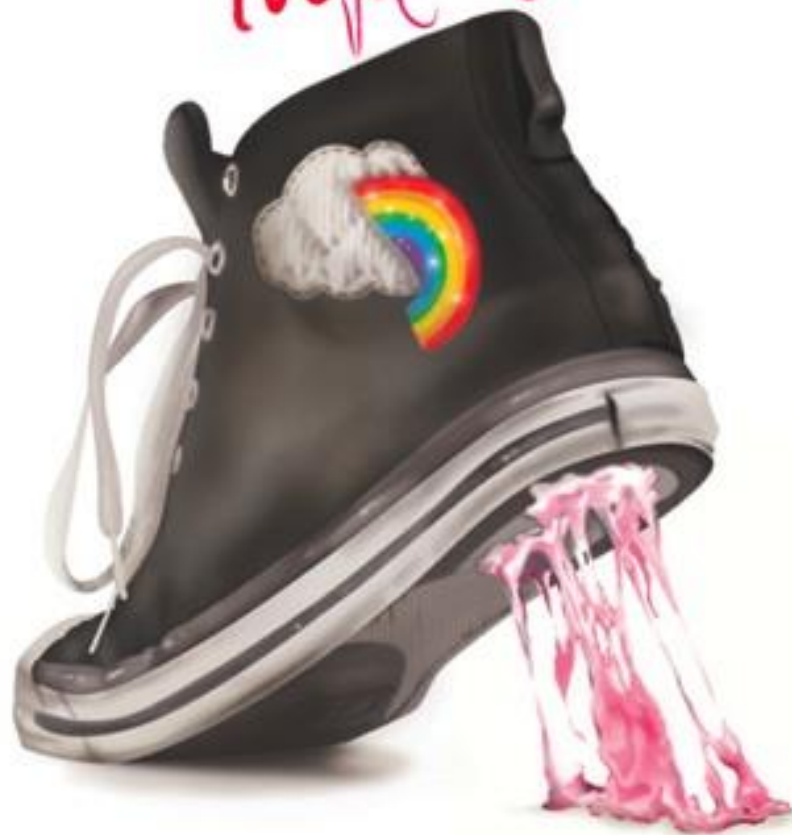


0.2 μm

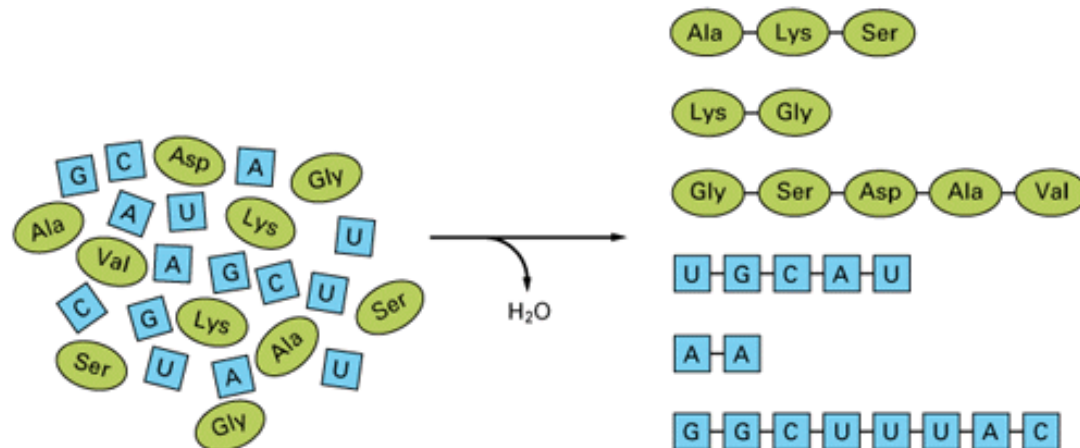
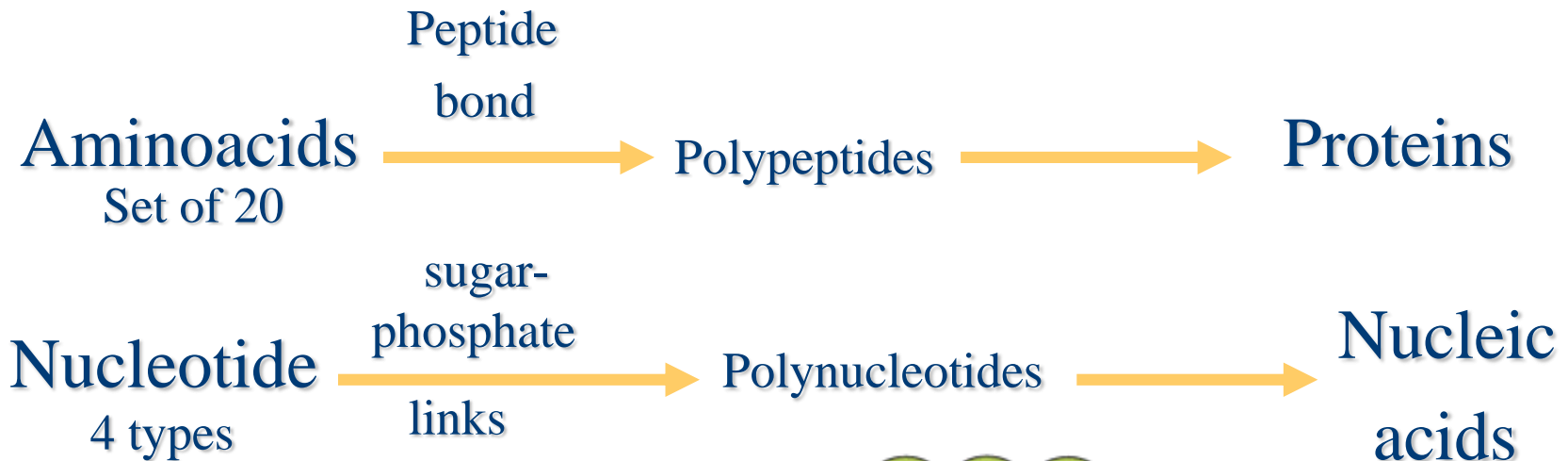
**life on earth would be impossible
without....**

FREE ENERGY

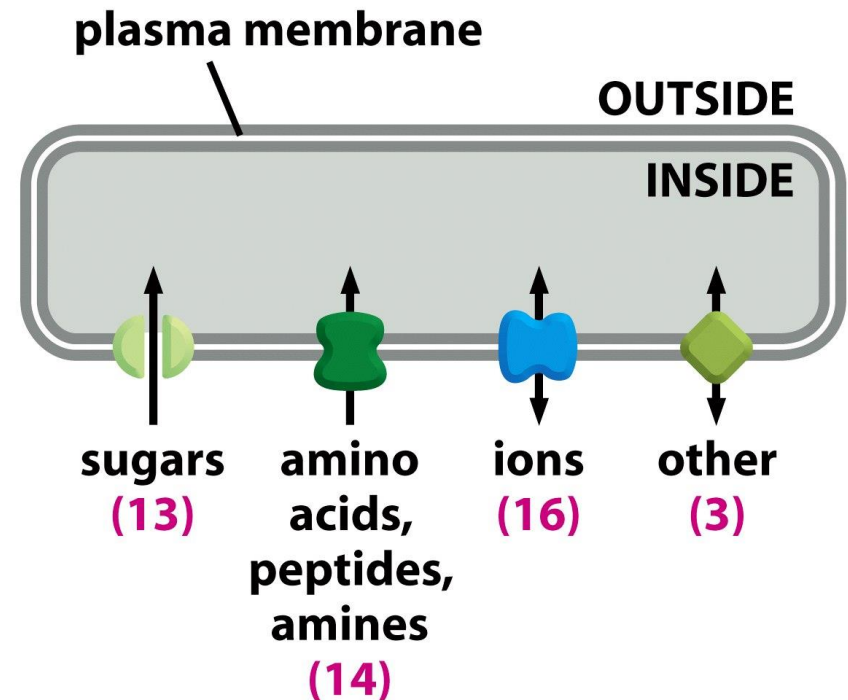
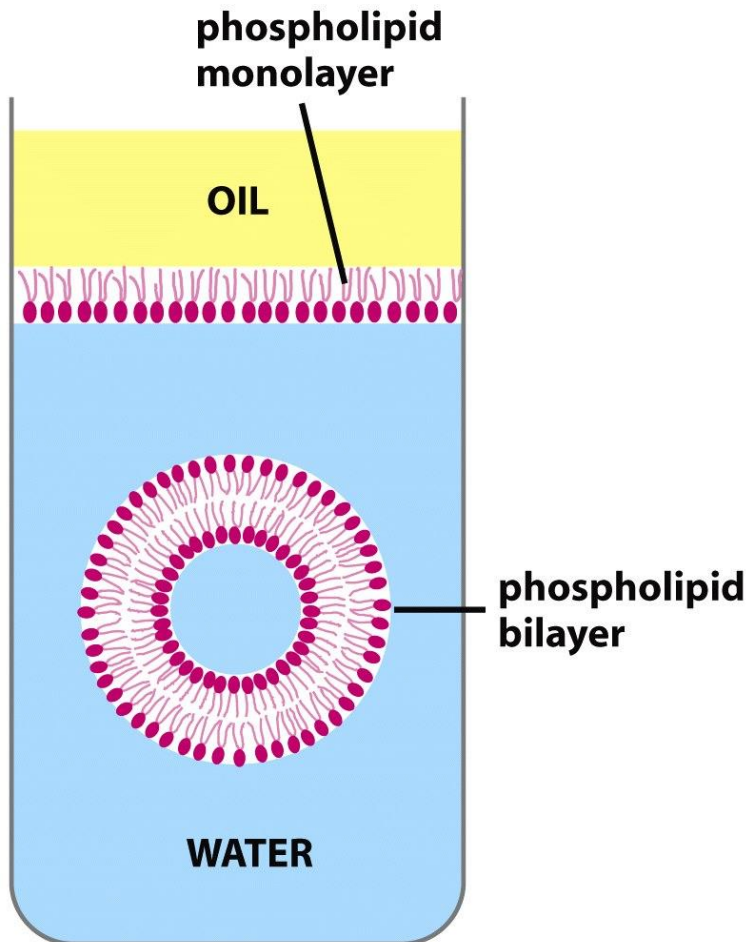
*Stuck
on
Nothing*



All Cells Function as Biochemical Factories Dealing with the Same Basic Molecular Building Blocks



All Cells Are Enclosed in a Plasma Membrane Across Which Nutrients and Waste Materials Must Pass



The set of transport **proteins** found in the membrane of the bacterium *Thermotoga maritima*.

CELL MEMBRANES

CELL -> AN OPEN SYSTEM

- **PLASMA MEMBRANE;**
- **ENDOMEMBRANES.**

**What is the first step when
building a house?**



PLASMA MEMBRANE:

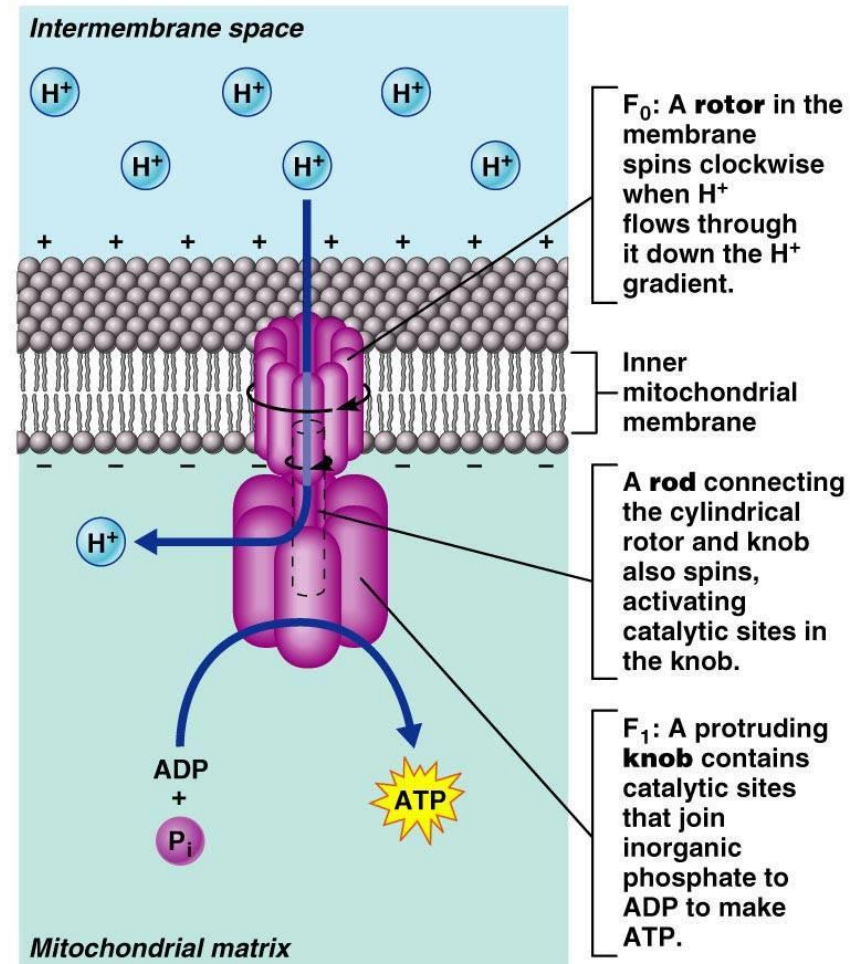
- **encloses the cell - defines its boundaries;**
- **relatively impermeable barrier to the passage of most water-soluble molecules;**
- **maintains the essential differences between the cytosol and the extracellular environment;**

PLASMA MEMBRANE:

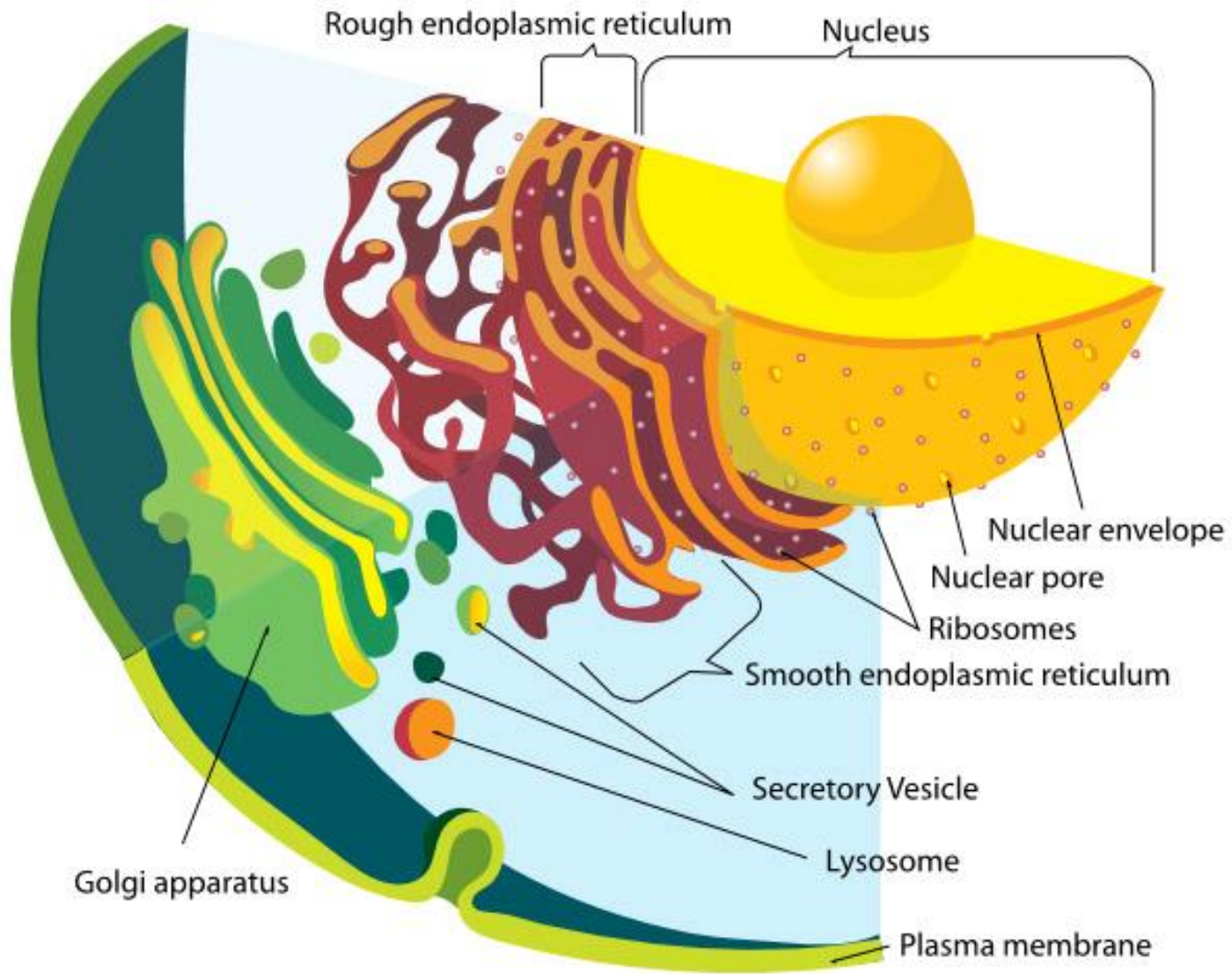
- **drive the transmembrane movement of selected solutes (carrier/channell);**
- **contains proteins (receptors) - act as sensors of external signals;**
- **adhesion (junctions): cell-cell or cell-ECM**

ENDOMEMBRANE SYSTEM:

- maintains the characteristic differences between the contents of each organelle and the cytosol;
- contains specialized membrane proteins (eg: mitochondria: *ATP synthase*)



ENDOMEMBRANE SYSTEM



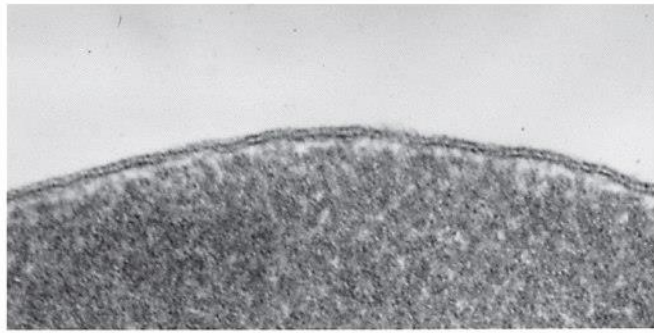
MEMBRANES:

- **all biological membranes - a common general structure: each is a very thin film of lipid and protein molecules, held together mainly by noncovalent interactions.**
- **dynamic, fluid structures, and most of their molecules are able to move about in its plane.**

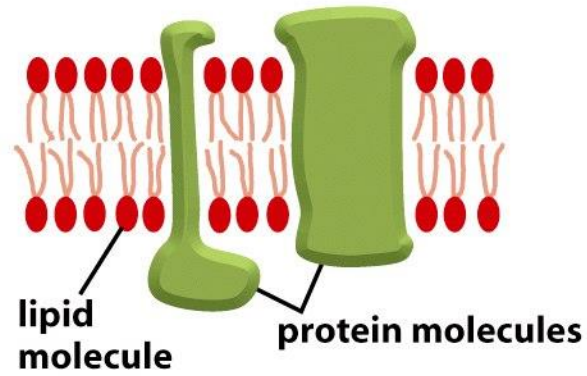
MEMBRANES:

- **LIPID BILAYER** - provides the basic fluid structure of the membrane - relatively impermeable barrier (5 nm thick).
- **PROTEIN MOLECULES** - span the lipid bilayer mediate nearly all of the other functions.

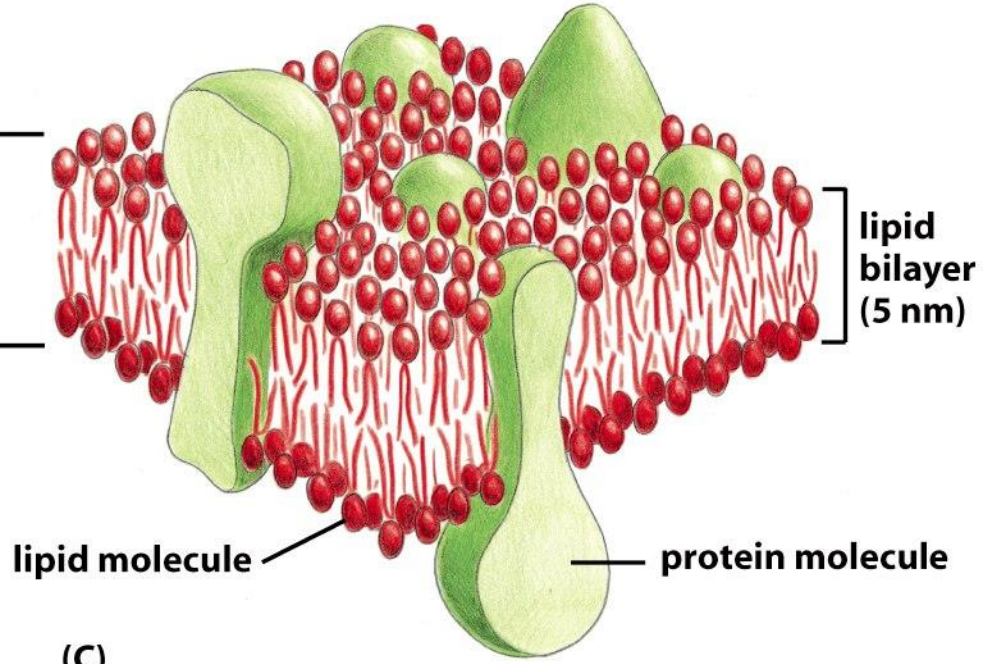
30% of the proteins that are encoded in an animal cell's genome are membrane proteins



(A)



(B)



(C)

Figure 10-1 *Molecular Biology of the Cell* (© Garland Science 2008)

LIPID BILAYER:

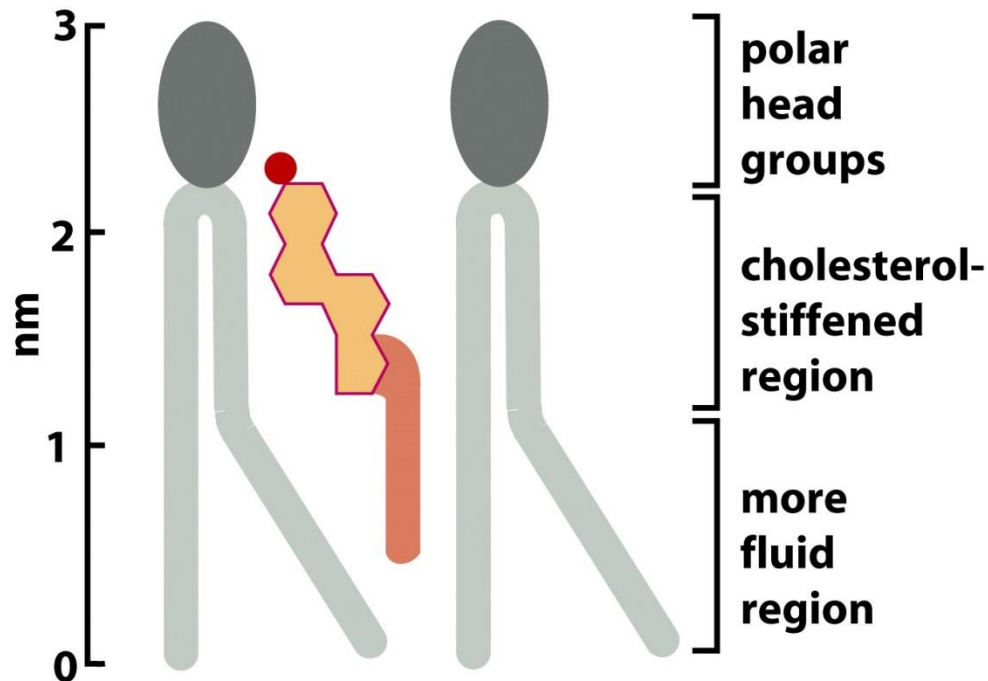
- **attributable to the special properties of the lipid molecules, which cause them to assemble spontaneously into bilayers even under simple artificial conditions**

LIPIDS:

- **50% of the mass of most animal cell membranes, nearly all of the remainder being proteins.**
- **amphipathic (or amphiphilic) - hydrophilic (“water-loving”) or polar end + a hydrophobic (“water-fearing”) or nonpolar end.**

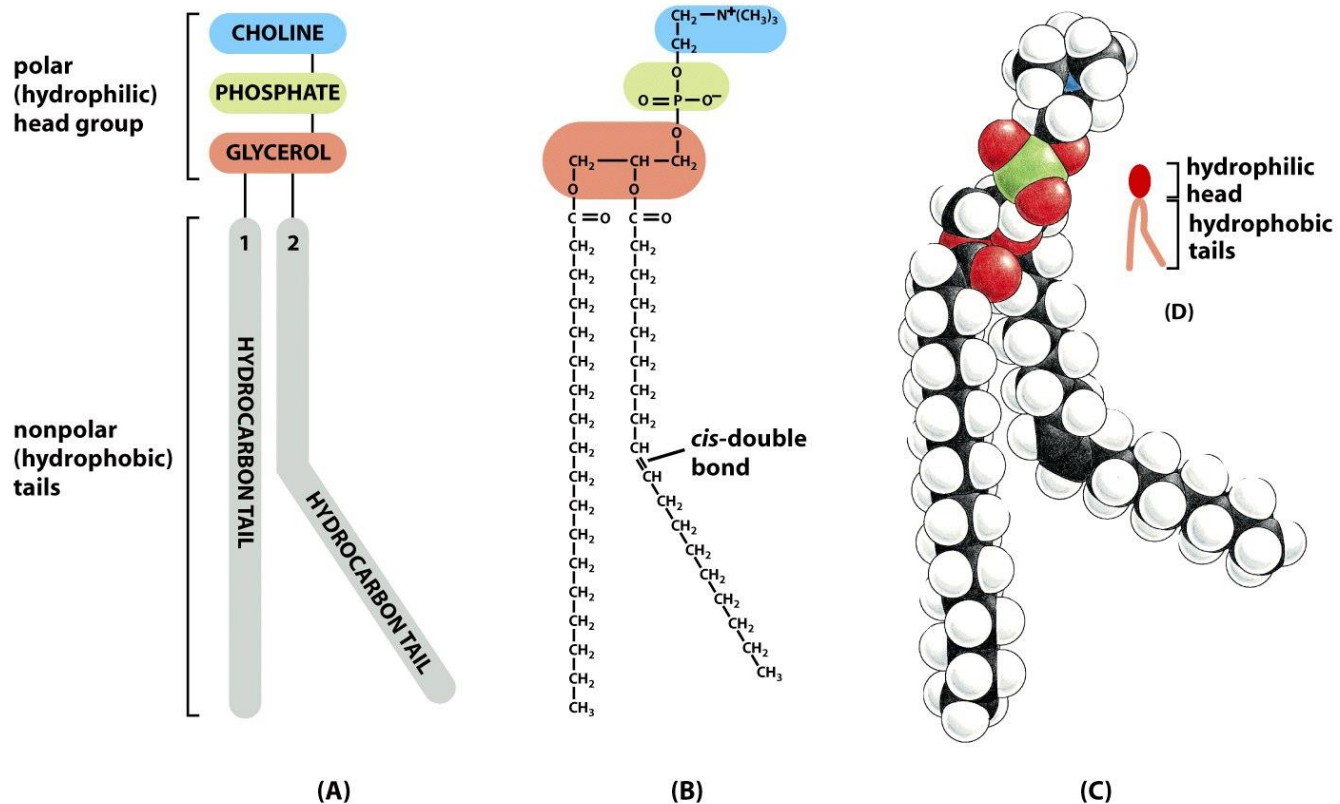
MEMBRANE LIPIDS:

- phospholipids
- glycolipids
- Cholesterol - up to one molecule for every phospholipid molecule (permeability).



PHOSPHOLIPIDS

- polar head group + two hydrophobic hydrocarbon tails. The tails are usually fatty acids (1 unsaturated + 1 saturated), and they can differ in length.



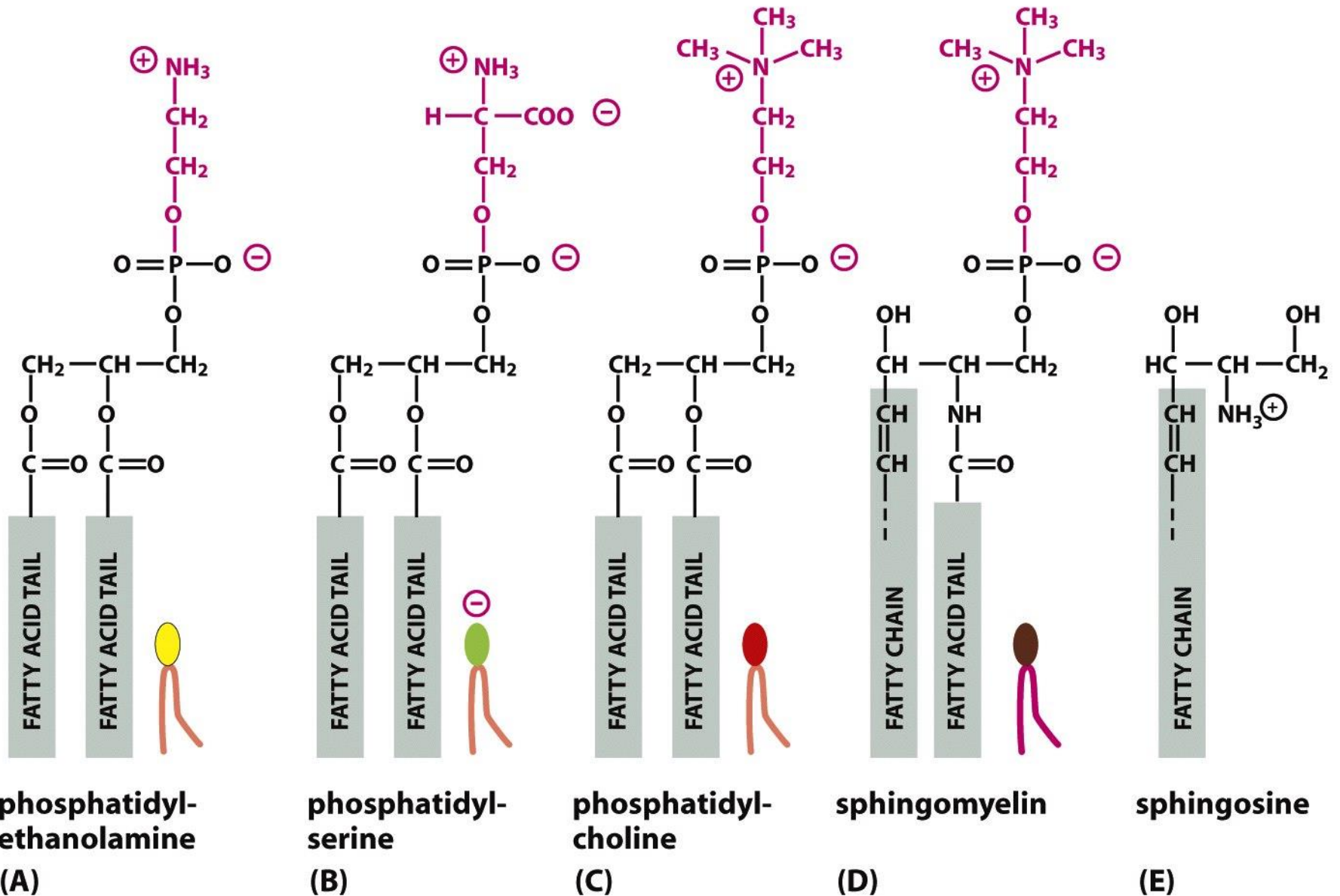
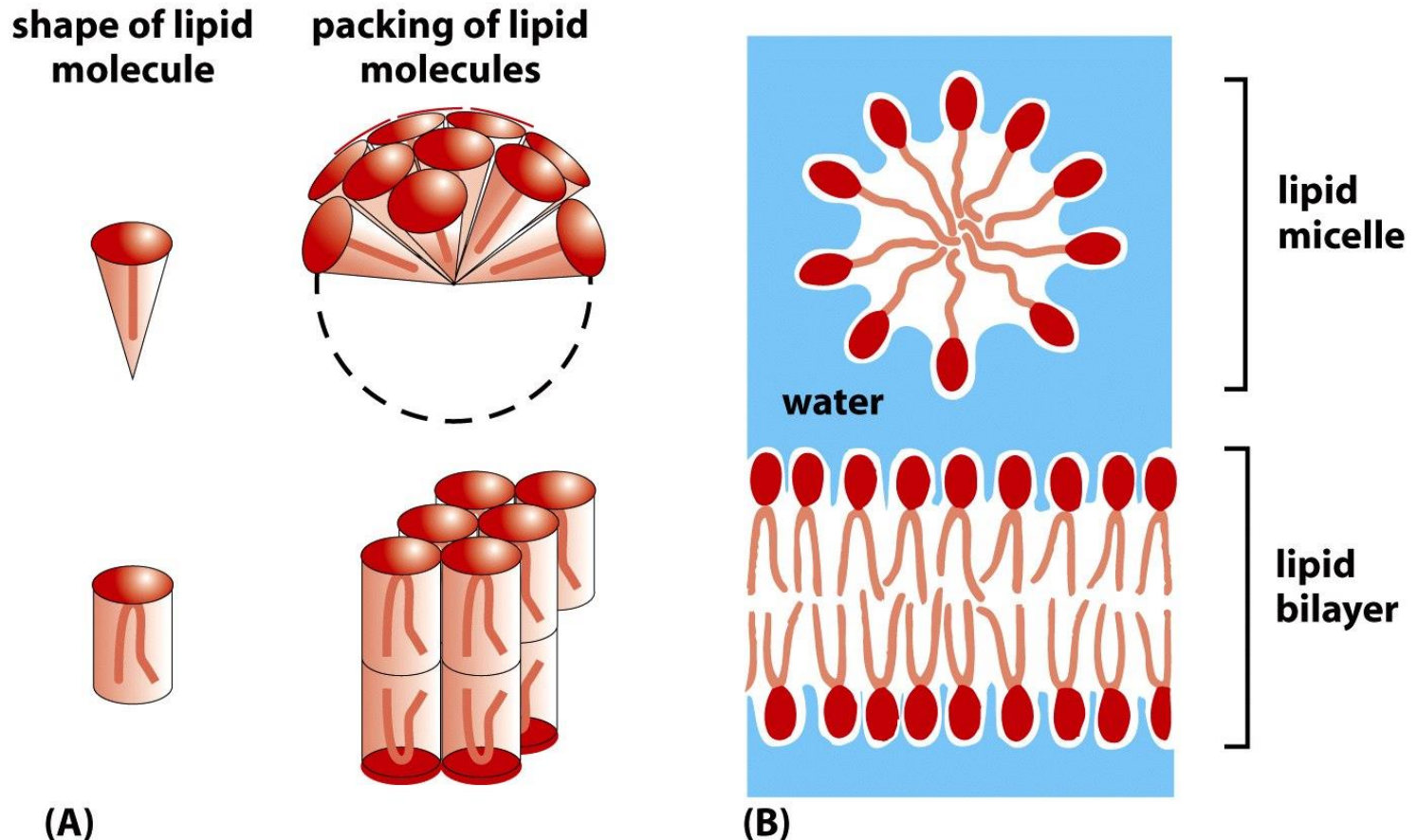


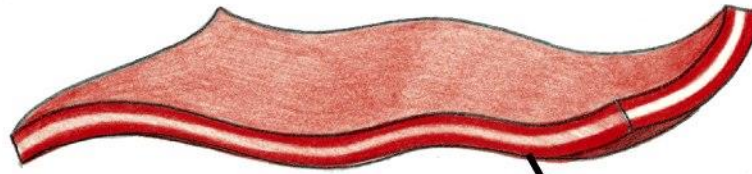
Figure 10-3 *Molecular Biology of the Cell* (© Garland Science 2008)

LIPIDS - Spontaneously Form Bilayers

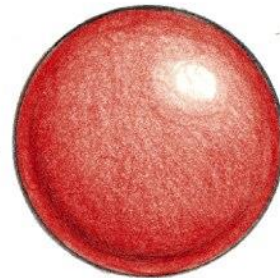
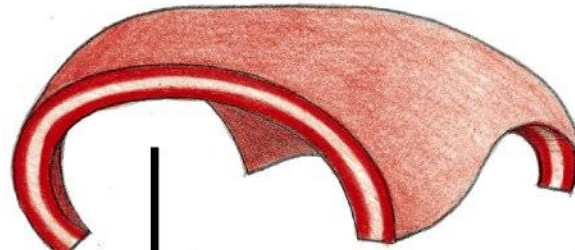
- The shape and amphipathic nature of the lipid molecules - cause them to form bilayers spontaneously in aqueous environments.



ENERGETICALLY UNFAVORABLE



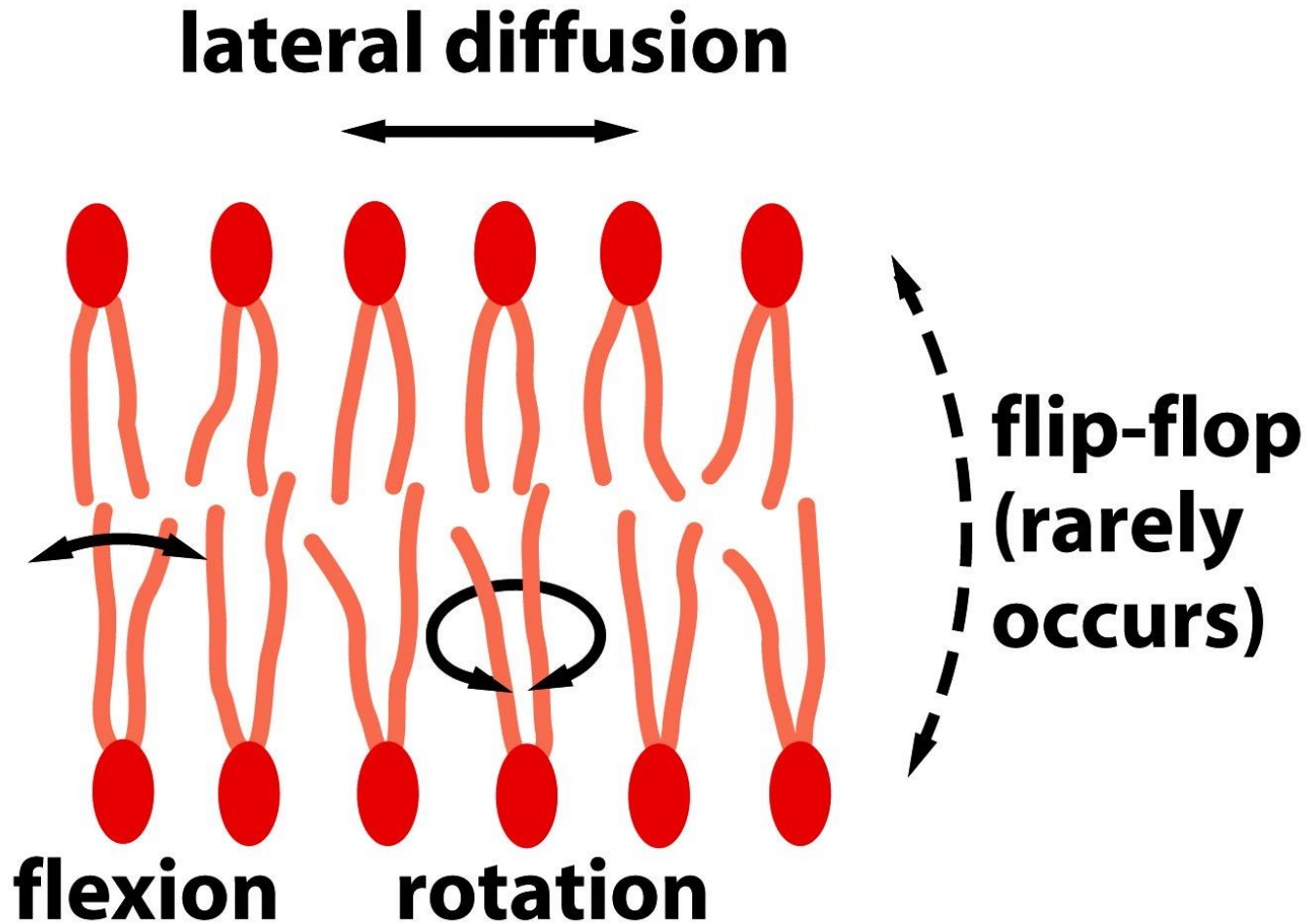
planar phospholipid bilayer
with edges exposed to water



sealed compartment
formed by phospholipid
bilayer

ENERGETICALLY FAVORABLE

The Lipid Bilayer Is a Two-dimensional Fluid

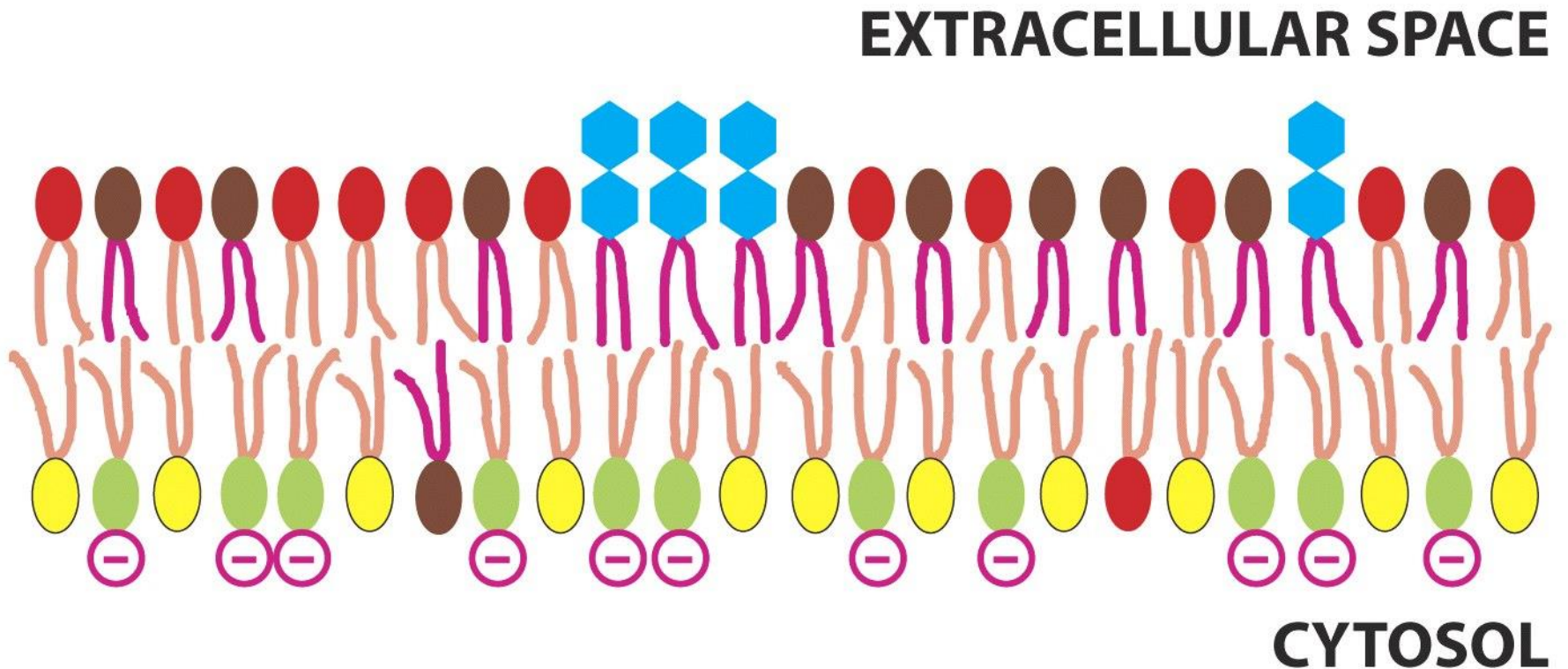


MEMBRANE FLUIDITY



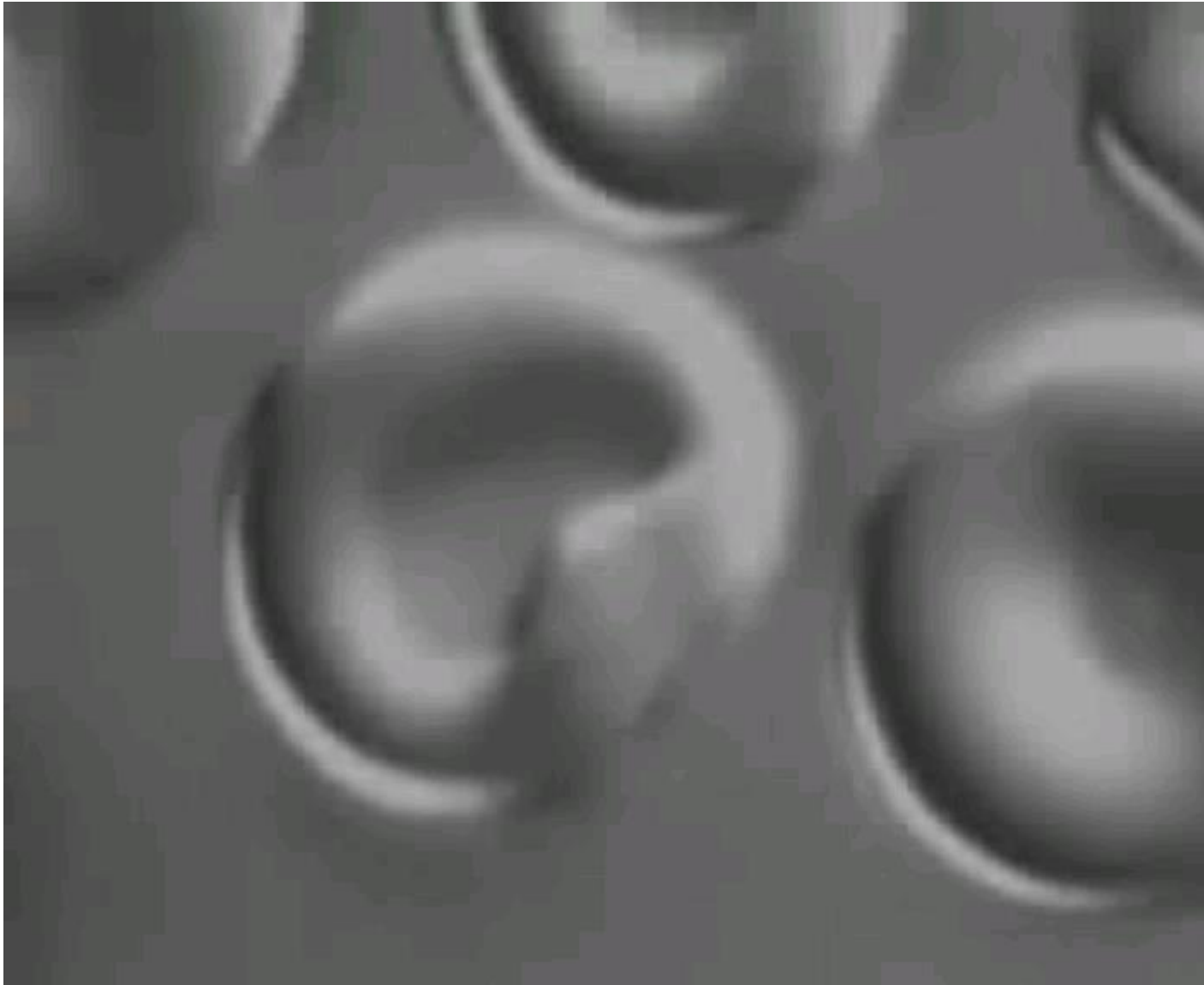
The Asymmetry of the Lipid Bilayer Is Functionally Important

- Glycolipids are found on the surface of all plasma membranes





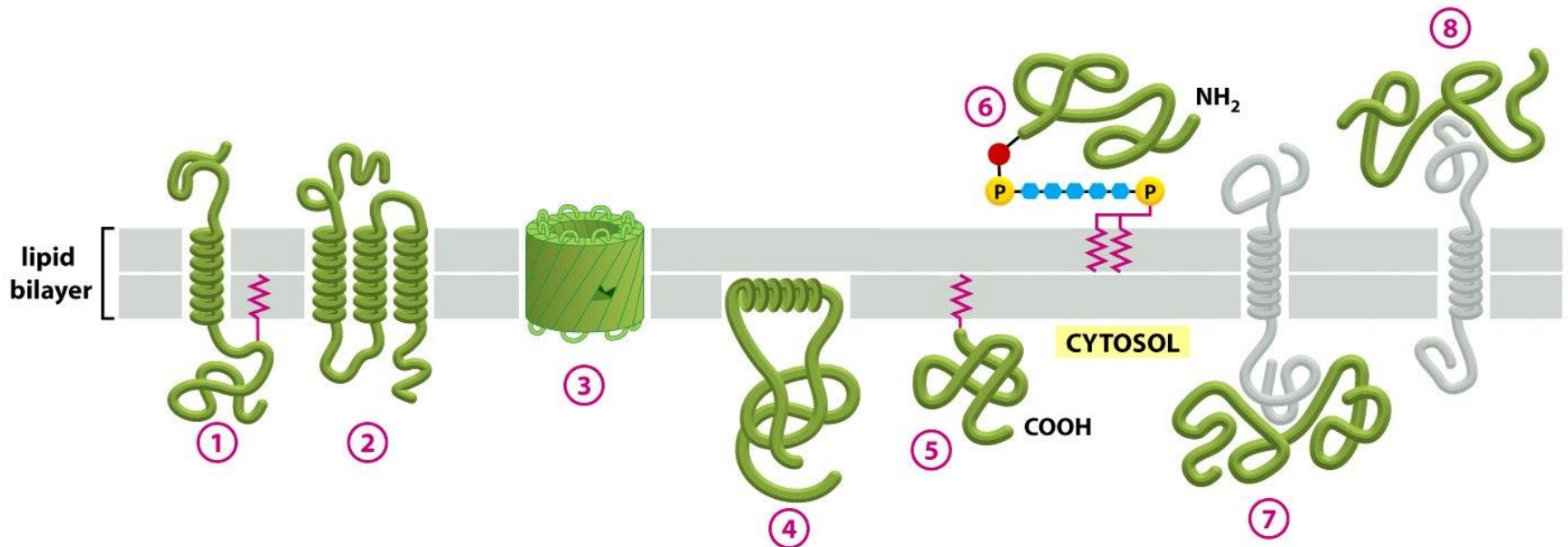
Elasticity of cell membranes



Membrane Proteins

- **perform most of the specific functions of membranes;**
- **give each type of membrane in the cell its characteristic functional properties;**
- **the amounts and types of proteins in a membrane are highly variable (eg: myelin membrane < 25% of the mb. Mass, internal membranes of mitochondria – aprox. 75%)**

Membrane Proteins - Associated with the Lipid Bilayer

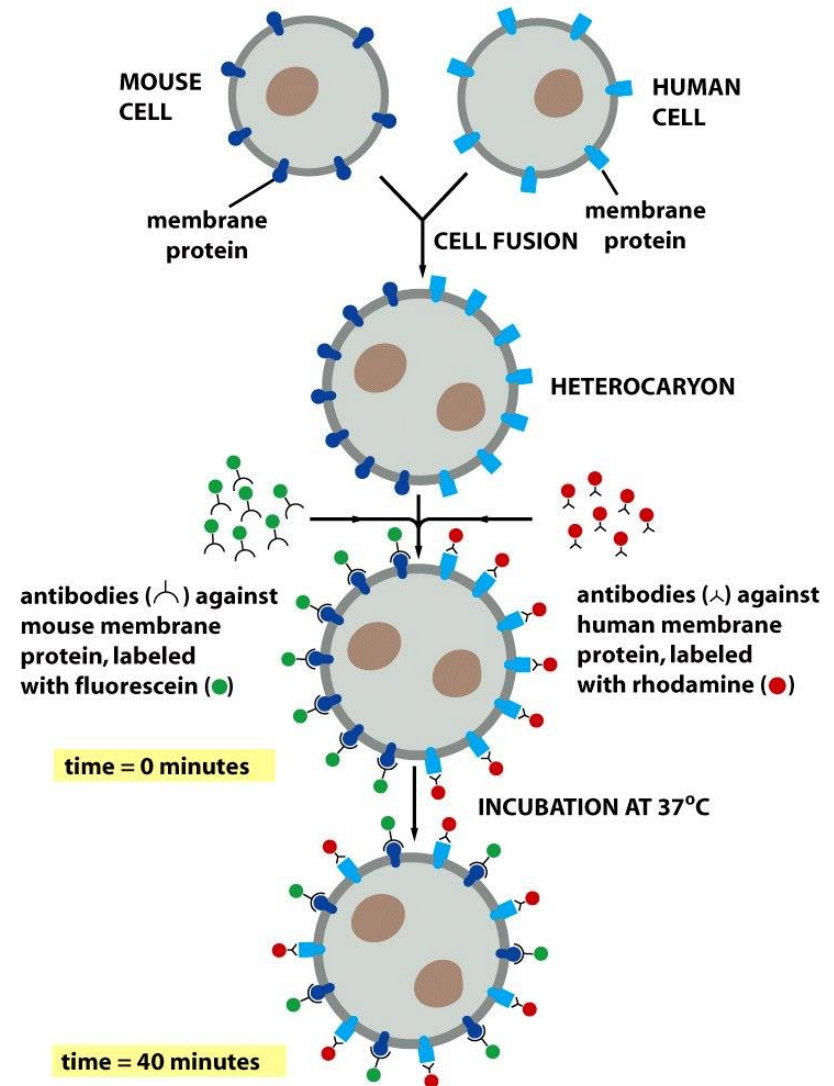


- Extend across the bilayer as (1) a single α helix, (2) as multiple α helices, or (3) β sheet
- Exposed at only one side of the membrane - anchored to the cytosolic surface (4)
- Attached to the bilayer solely by a covalently attached lipid chain (5)
- Attached via an oligosaccharide linker to phosphatidylinositol in the noncytosolic monolayer (6)
- Attached to the membrane only by noncovalent interactions with other membrane proteins (7, 8)

Mobility of integral membrane proteins

Frye & Edidin experiment (1970)

=> "fluid mosaic" model of the cell membrane by Singer and Nicolson (1972)



Mobility of integral membrane proteins

Measuring the rate of lateral diffusion of a membrane protein by photobleaching techniques.

