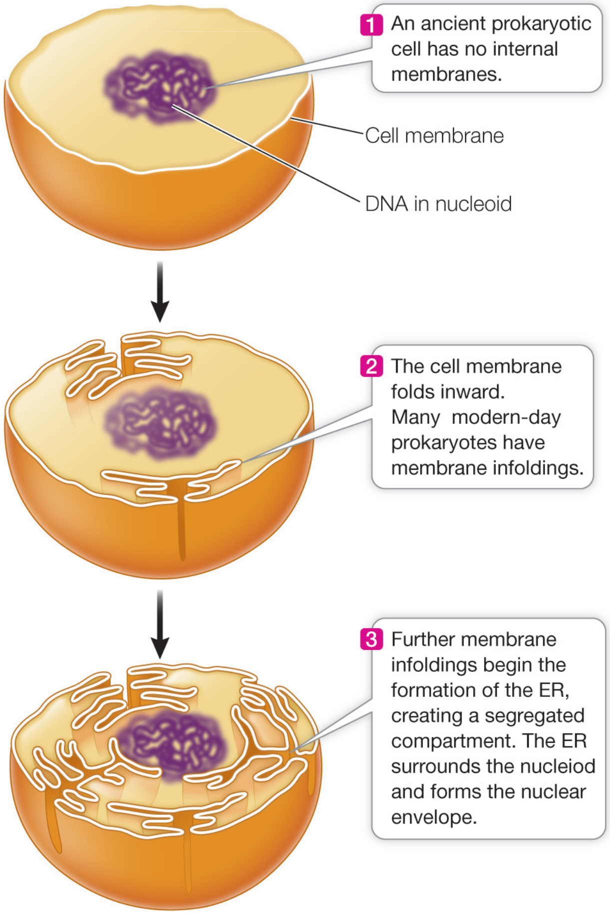
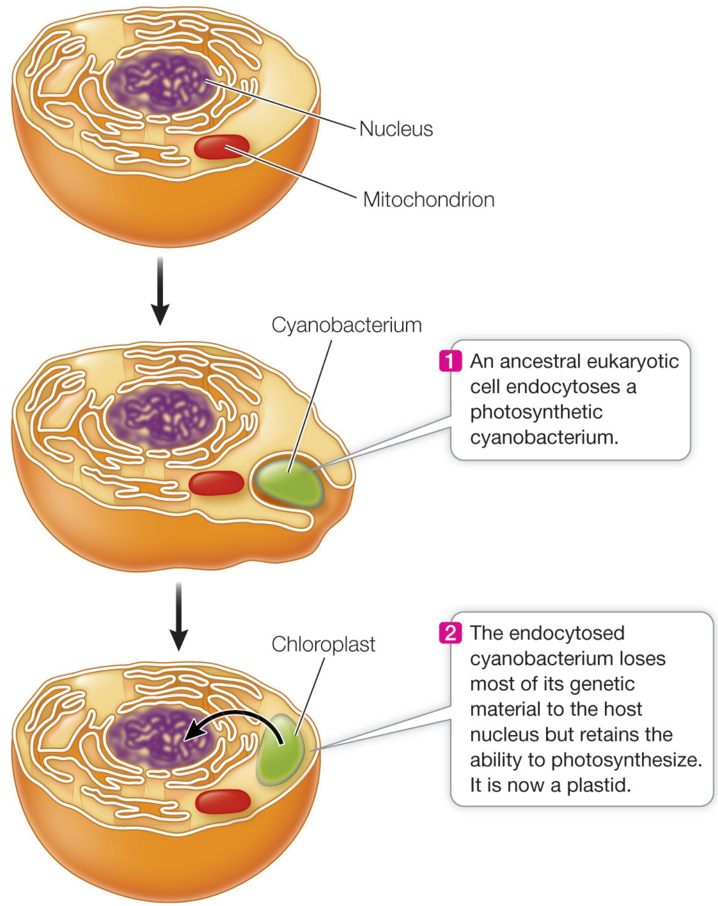
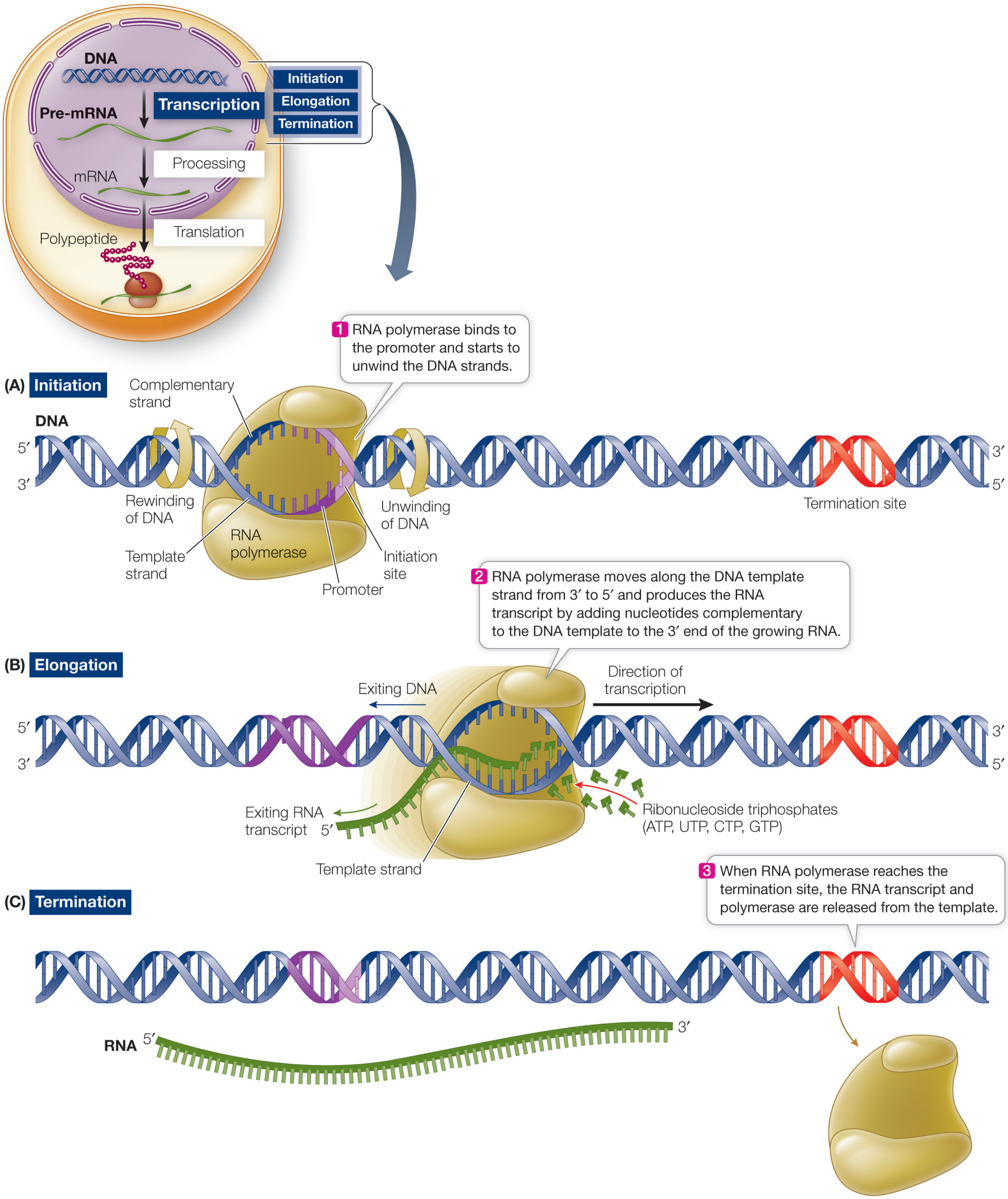
(A) Hypothetical evolution of the ER

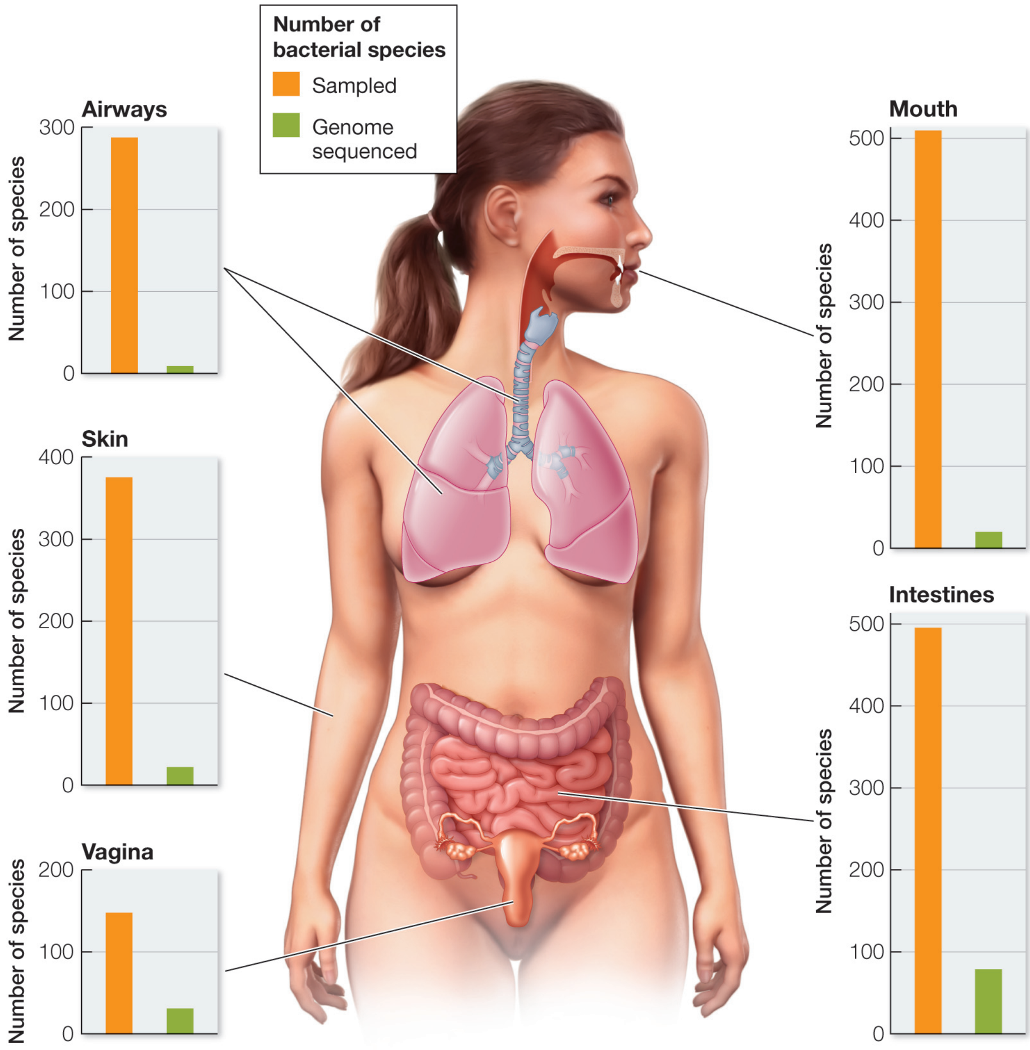


(B) Evolution of the chloroplast according to the Theory of Endosymbiosis





DNA
Pre-mRNA
Transcription
Initiation
Elongation
Termination
Processing
mRNA
Translation
Polypeptide
1 RNA polymerase binds to the promoter and starts to unwind the DNA strands.
(A) Initiation
Complementary strand
DNA
5′
3′
Rewinding of DNA
Template strand
RNA polymerase
Promoter
Unwinding of DNA
Initiation site
Termination site
3′
5′
2 RNA polymerase moves along the DNA template strand from 3′ to 5′ and produces the RNA transcript by adding nucleotides complementary to the DNA template to the 3′ end of the growing RNA.
(B) Elongation
Exiting DNA
Direction of transcription
5′
3′
3′
5′
Exiting RNA transcript
5′
Ribonucleoside triphosphates (ATP, UTP, CTP, GTP)
Template strand
3 When RNA polymerase reaches the termination site, the RNA transcript and polymerase are released from the template.
(C) Termination
RNA
5′
3′



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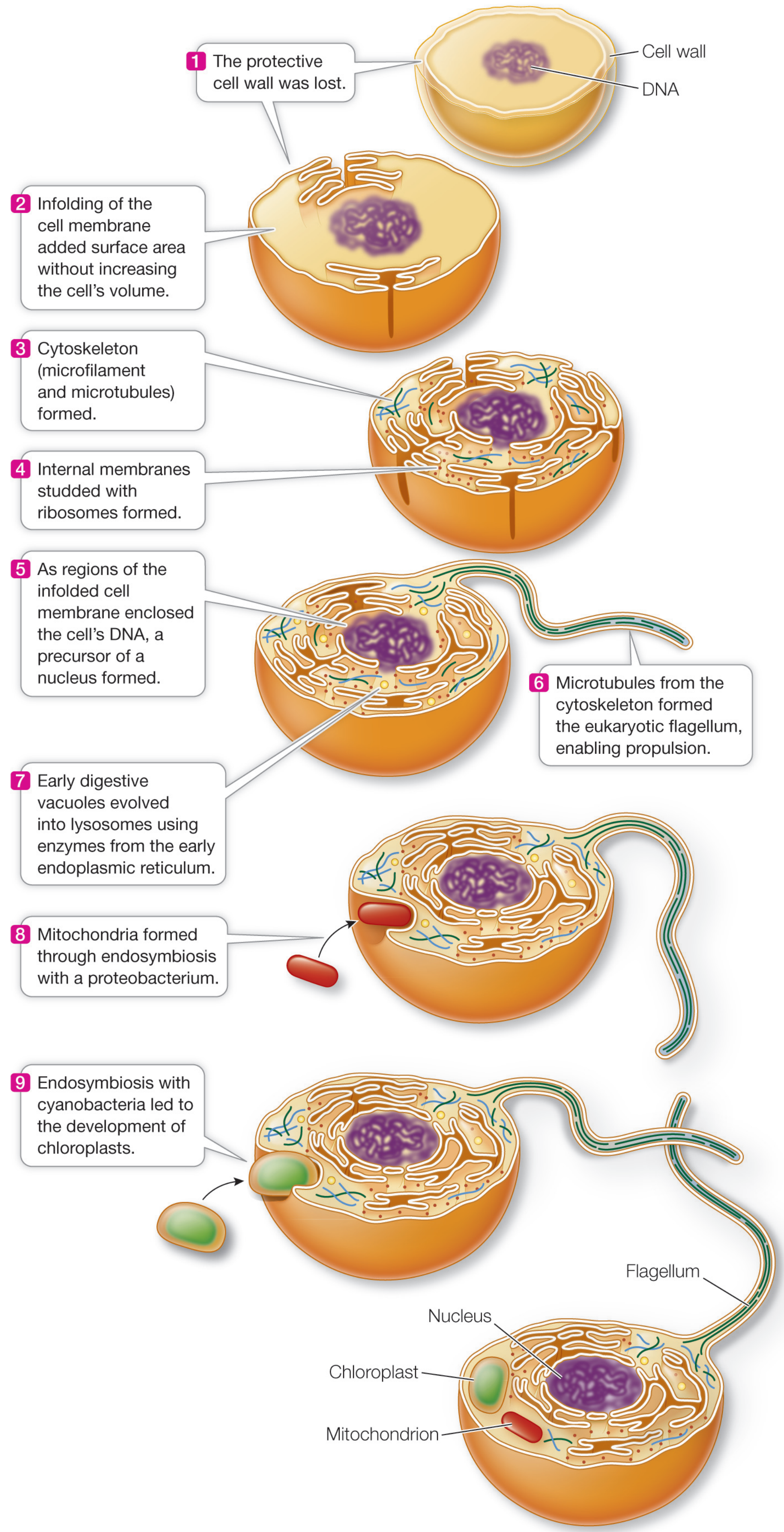

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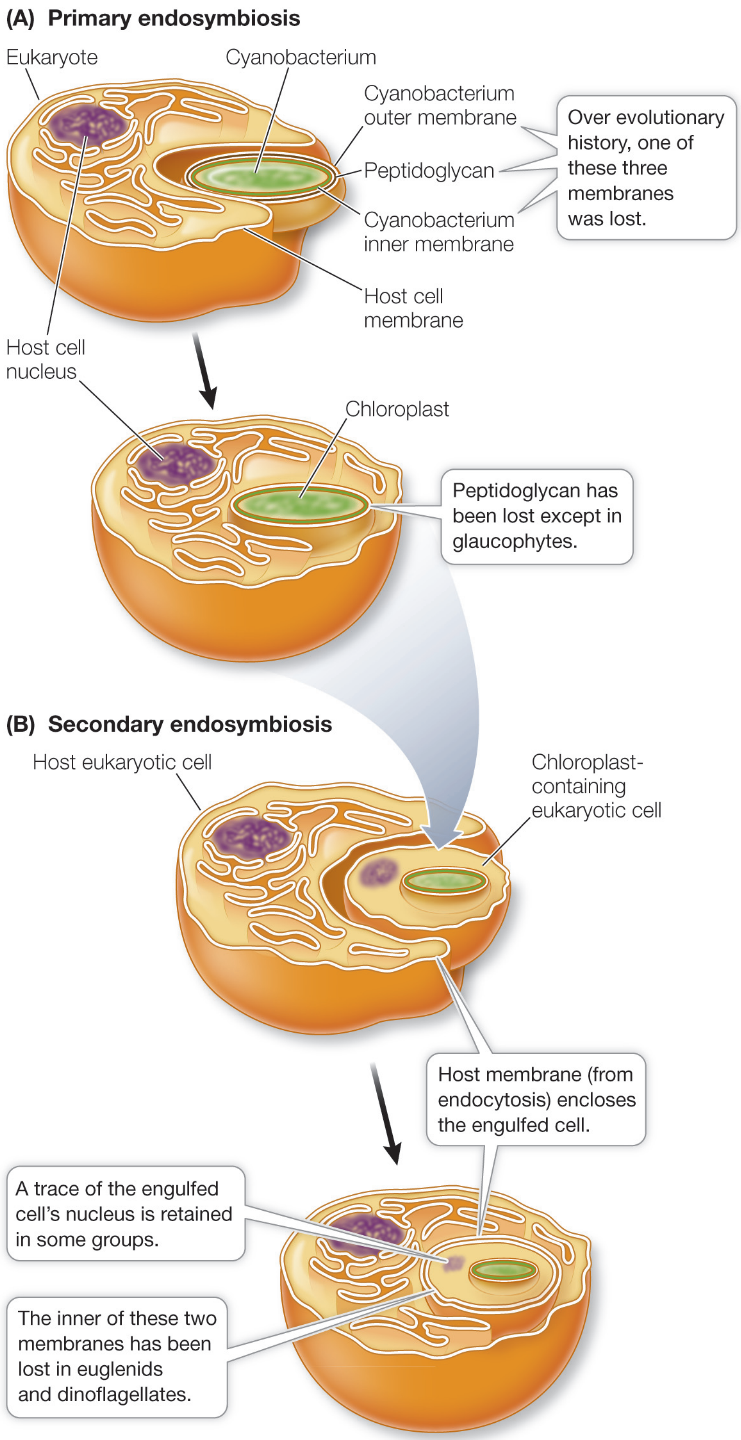
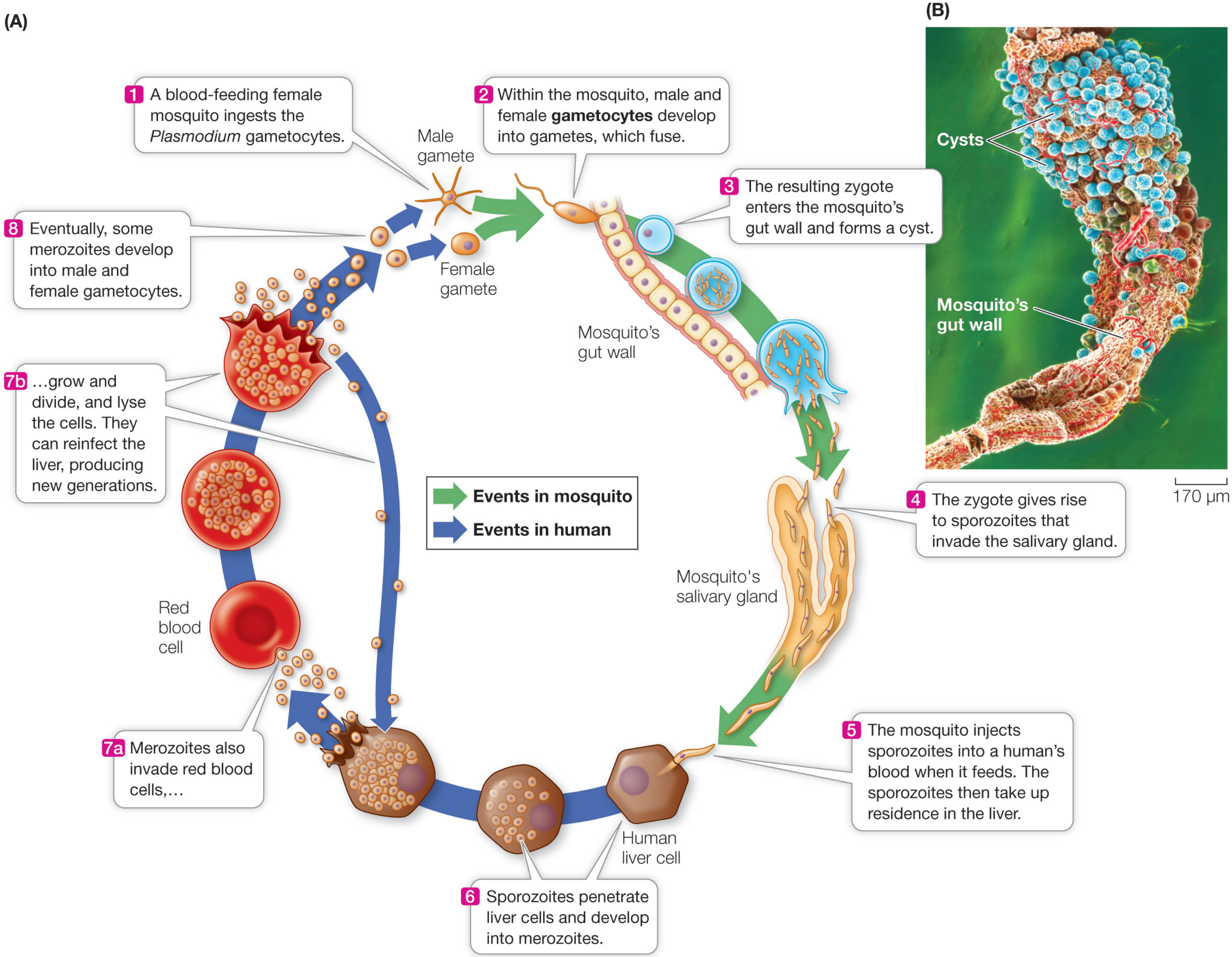
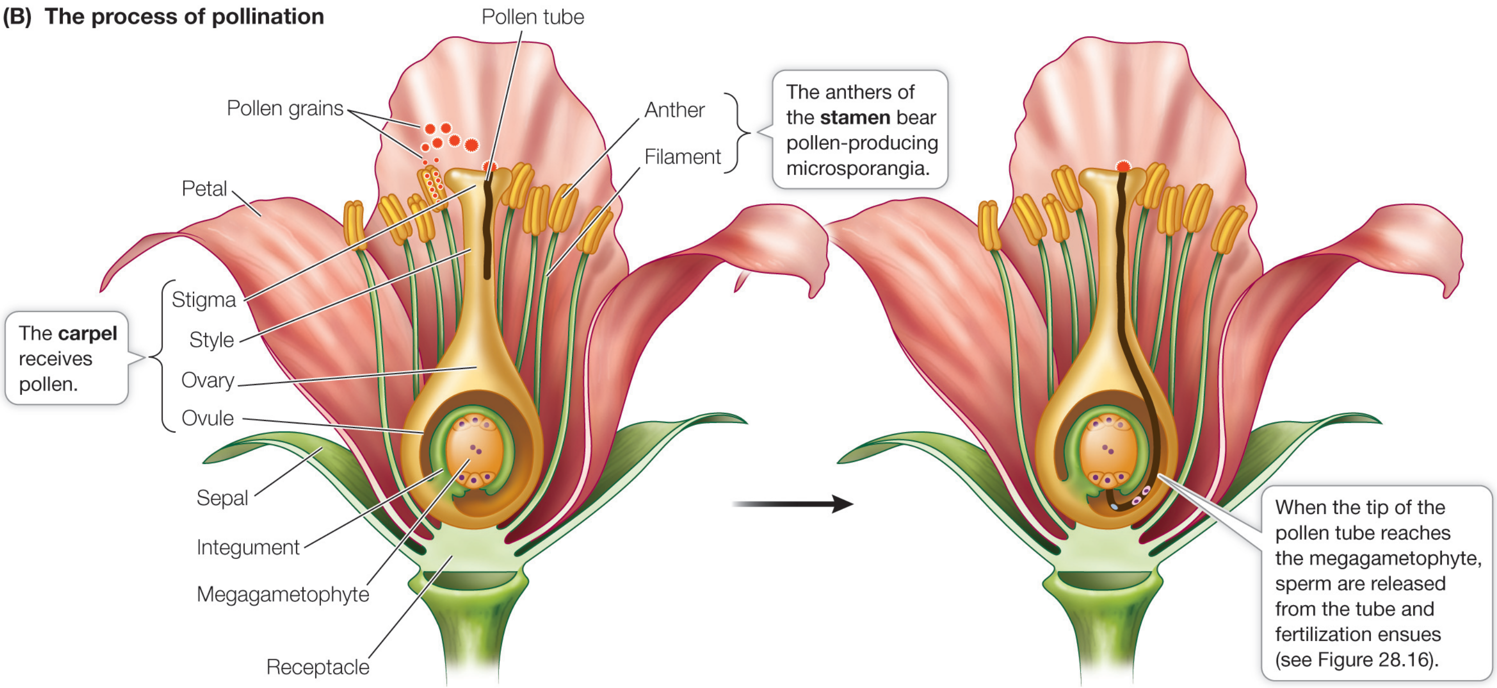


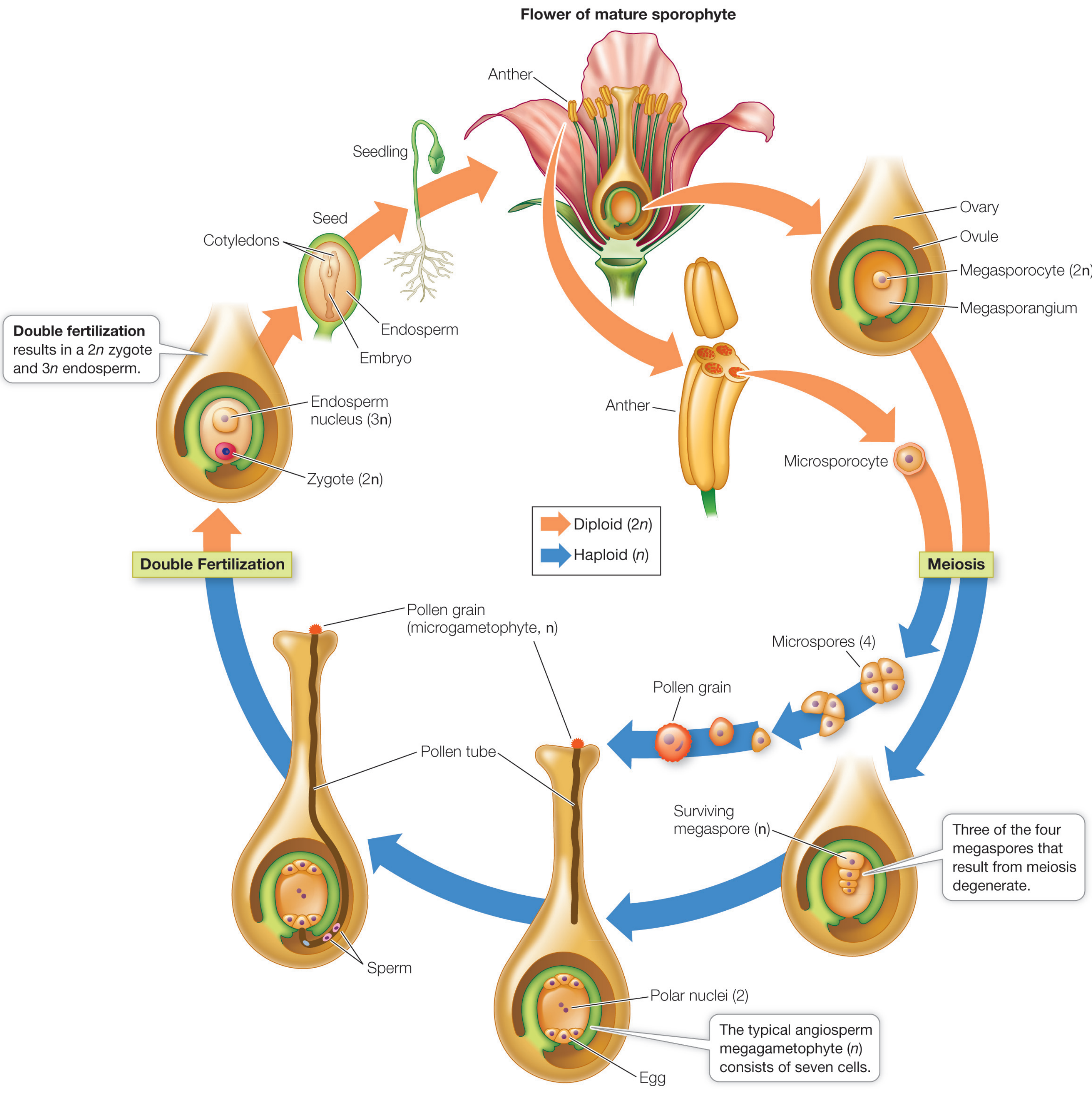
(A) Primary endosymbiosis
Eukaryote
Cyanobacterium
Cyanobacterium outer membrane
Peptidoglycan
Cyanobacterium inner membrane
Over evolutionary history, one of these three membranes was lost.
Host cell membrane
Host cell nucleus
Chloroplast
Peptidoglycan has been lost except in glaucophytes.
(B) Secondary endosymbiosis
Host eukaryotic cell
Chloroplast-containing eukaryotic cell
Host membrane (from endocytosis) encloses the engulfed cell.
A trace of the engulfed cell's nucleus is retained in some groups.
The inner of these two membranes has been lost in euglenids and dinoflagellates.



(A)
1 A blood-feeding female mosquito ingests the *Plasmodium* gametocytes.
2 Within the mosquito, male and female **gametocytes** develop into gametes, which fuse.
Male gamete
Female gamete
3 The resulting zygote enters the mosquito's gut wall and forms a cyst.
Mosquito's gut wall
4 The zygote gives rise to sporozoites that invade the salivary gland.
Mosquito's salivary gland
5 The mosquito injects sporozoites into a human's blood when it feeds. The sporozoites then take up residence in the liver.
Human liver cell
6 Sporozoites penetrate liver cells and develop into merozoites.
7a Merozoites also invade red blood cells,…
Red blood cell
7b …grow and divide, and lyse the cells. They can reinfect the liver, producing new generations.
8 Eventually, some merozoites develop into male and female gametocytes.
Events in mosquito
Events in human
(B)
Cysts
Mosquito's gut wall
170 µm

(B) The process of pollination





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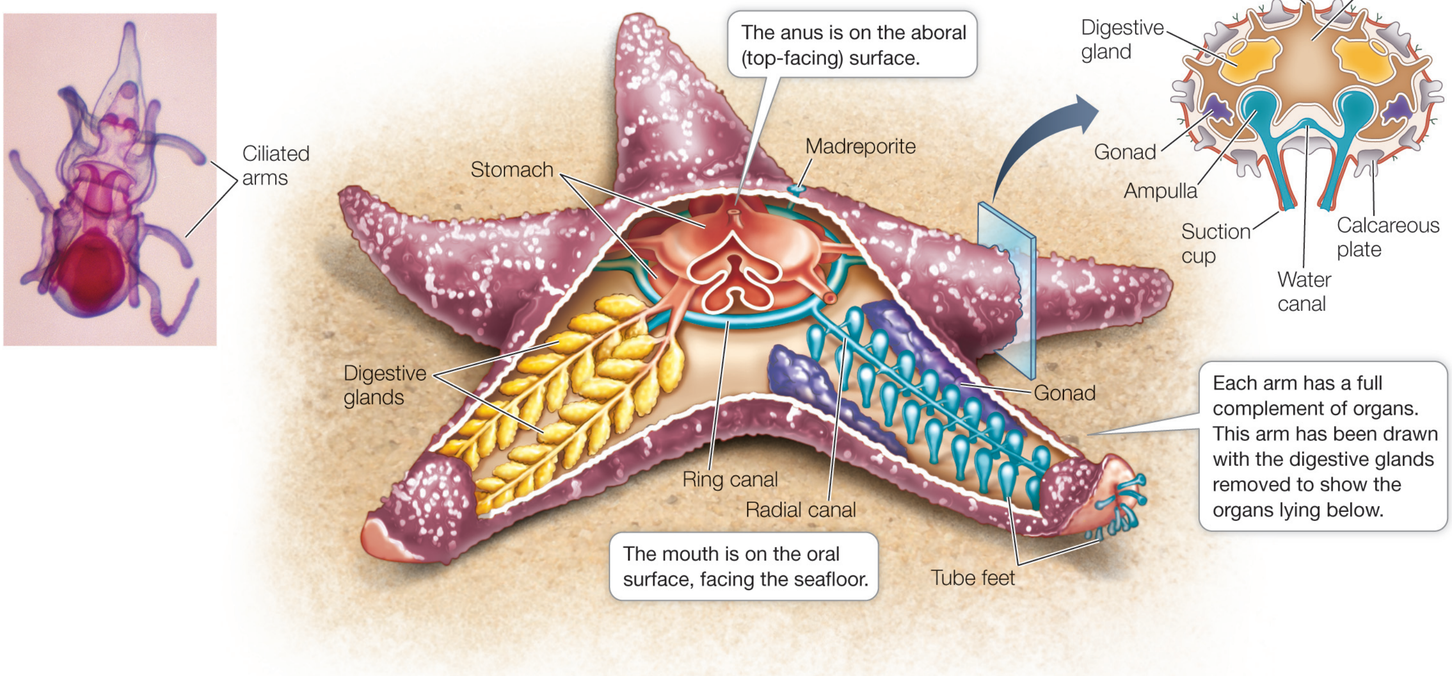
(A) Sea star larva
(bilateral symmetry)

(B) Adult sea star
(pentaradial symmetry)



Pineal gland
Melatonin: regulates biological rhythms

Thyroid gland (see Figures 40.13 and 40.15)
Thyroxine (T_3 and T_4): increases cell metabolism; essential for growth and neural development
Calcitonin: stimulates incorporation of calcium into bone

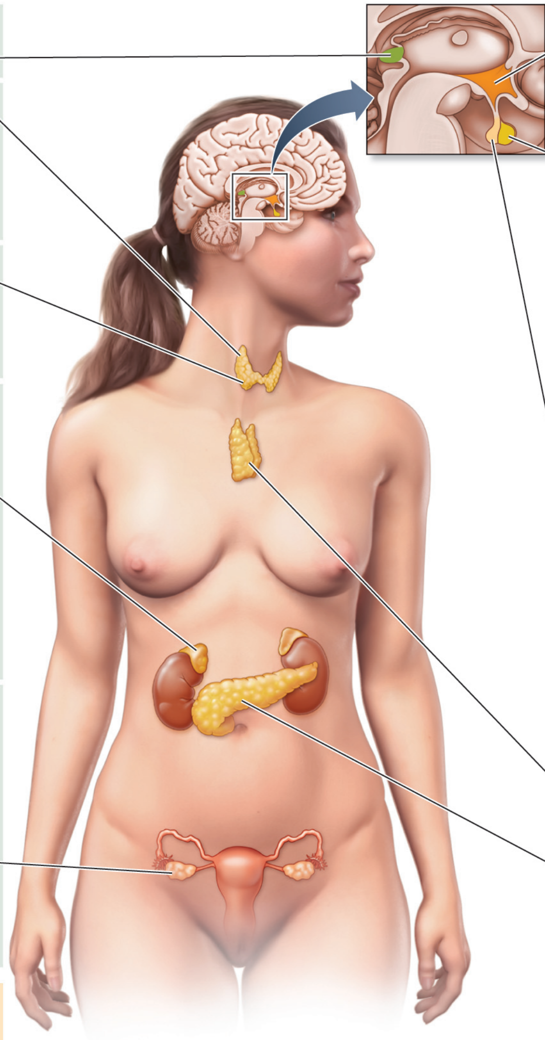
Parathyroid glands (on posterior surface of thyroid; see Figure 40.15)
Parathyroid hormone (PTH): stimulates release of calcium from bone and absorption of calcium by gut and kidney

Adrenal gland (see Figure 40.18)
Cortex
Cortisol: mediates metabolic responses to stress
Aldosterone: involved in salt and water balance
Sex steroids

Medulla
Epinephrine (adrenaline) and **norepinephrine** (noradrenaline): stimulate immediate fight-or-flight reactions

Gonads (see Chapter 42)
Testes (male)
Testosterone: development and maintenance of male sexual characteristics

Ovaries (female)
Estrogens: development and maintenance of female sexual characteristics
Progesterone: supports pregnancy



Hypothalamus (see Figure 40.6)
Release and release-inhibiting neurohormones control the anterior pituitary; **ADH** and **oxytocin** are transported to and released from the posterior pituitary

Anterior pituitary (see Figure 40.7)
Thyrotropin (TSH): activates the thyroid gland
Follicle-stimulating hormone (FSH): in females, stimulates maturation of ovarian follicles; in males, stimulates spermatogenesis
Luteinizing hormone (LH): in females, triggers ovulation and ovarian production of estrogens and progesterone; in males, stimulates production of testosterone
Corticotropin (ACTH): stimulates adrenal cortex to secrete cortisol
Growth hormone (GH): stimulates protein synthesis and growth
Prolactin: stimulates milk production
Melanocyte-stimulating hormone (MSH): stimulates production of the pigment melanin
Endorphins and enkephalins: pain control

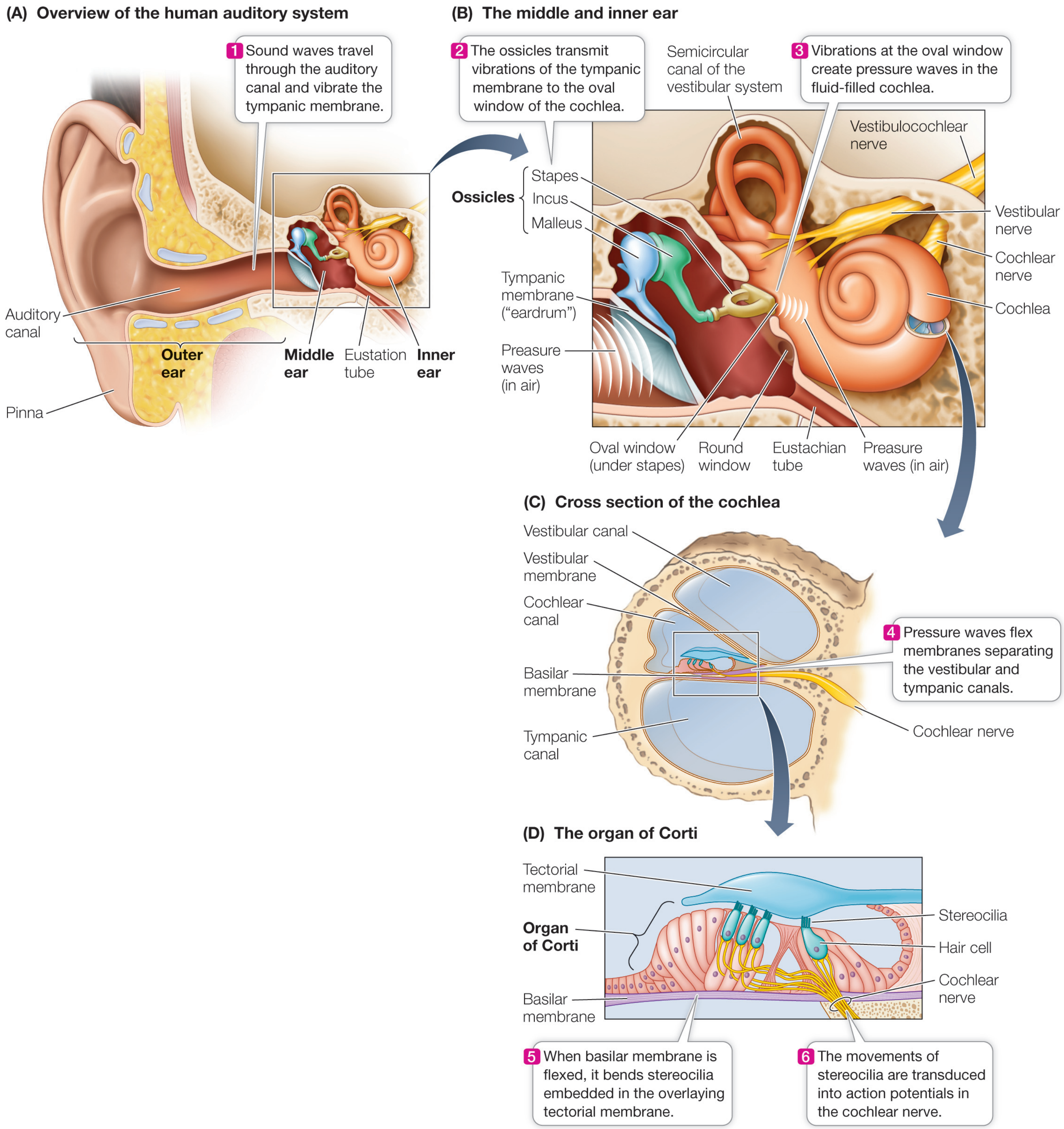
Posterior pituitary (see Figure 40.6)
Receives and releases two hypothalamic hormones:
Oxytocin: stimulates contraction of uterus, flow of milk, interindividual bonding
Antidiuretic hormone (ADH; also known as vasopressin): promotes water conservation by kidneys

Thymus (diminishes in adults)
Thymosin: activates immune system T cells

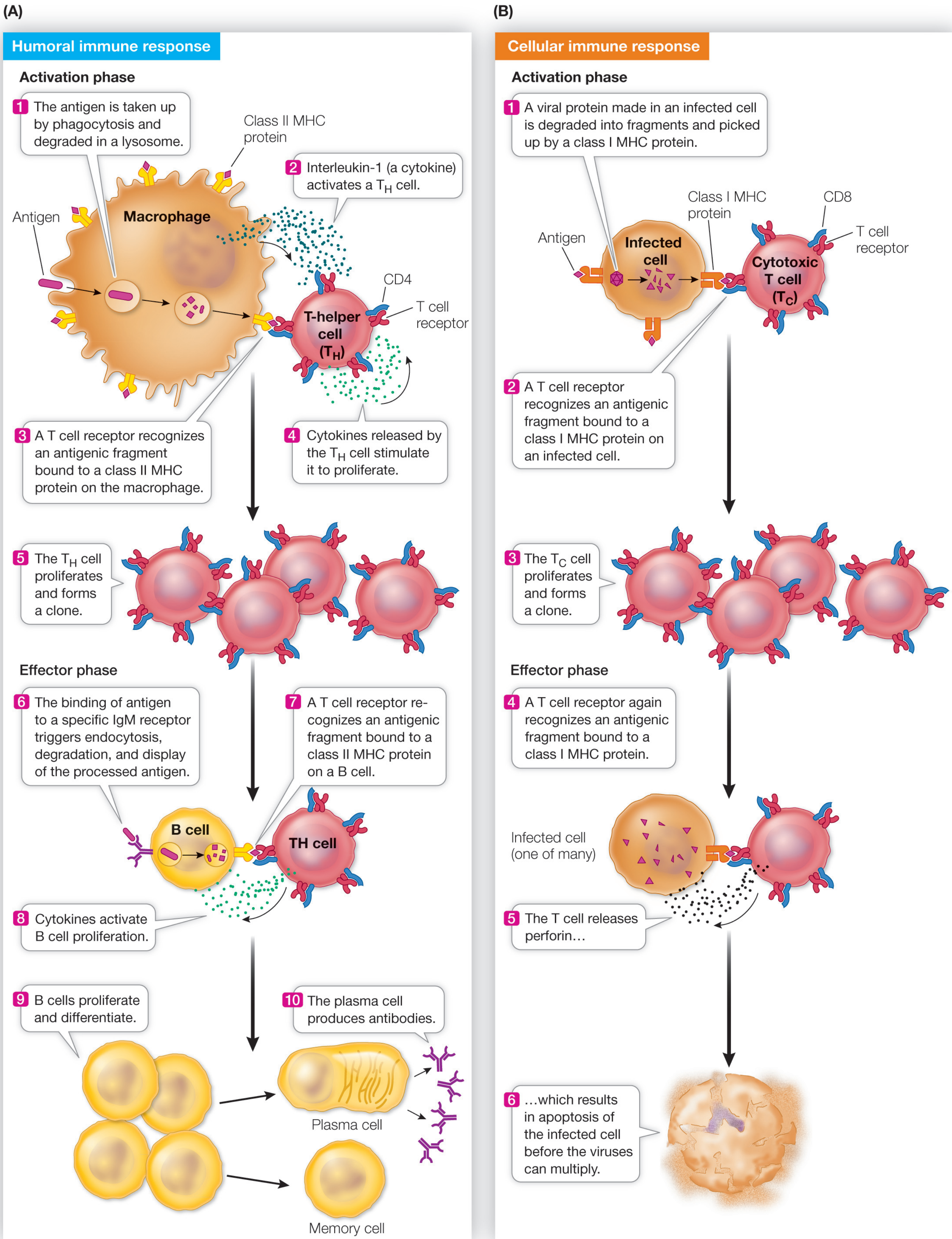
Pancreas (islets of Langerhans)
Insulin: stimulates cells to take up and use glucose
Glucagon: stimulates liver to release glucose
Somatostatin: slows release of insulin and glucagon and digestive tract functions

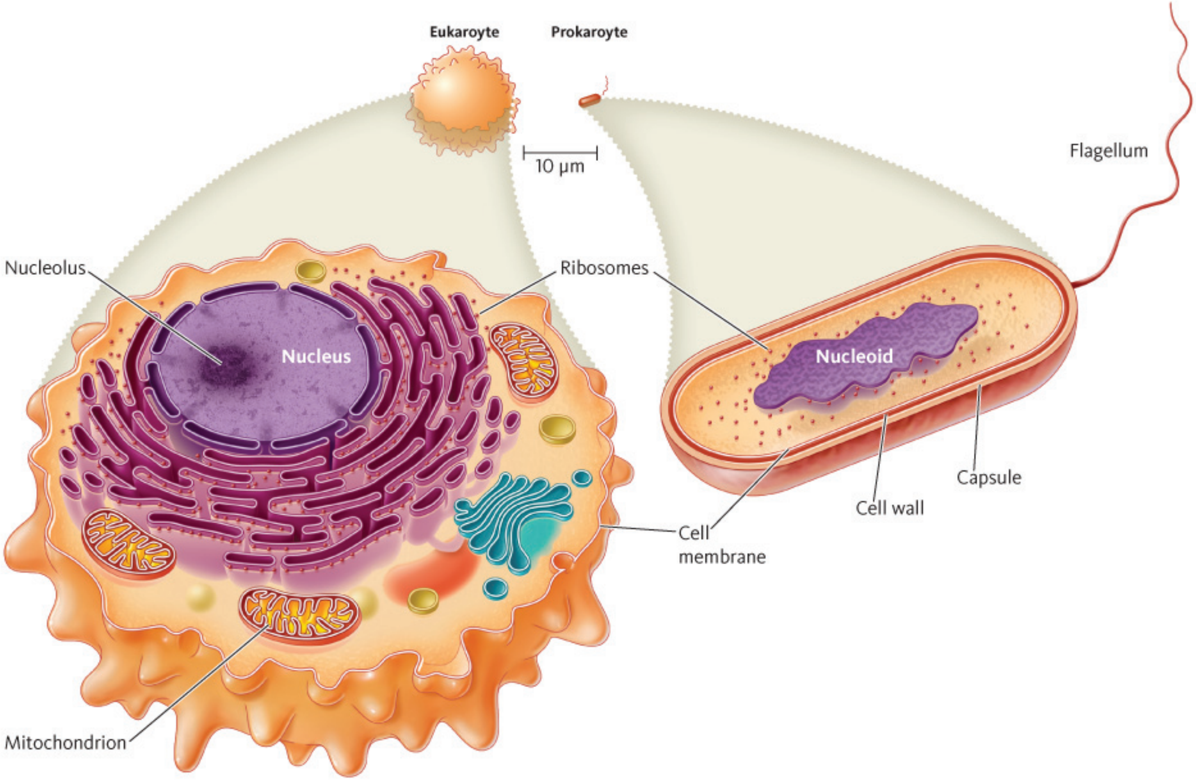
Other organs include cells that produce and secrete hormones

Organ	Hormone
Adipose tissue	Leptin
Heart	Atrial natriuretic peptide
Kidney	Erythropoietin
Stomach	Gastrin, ghrelin
Intestine	Secretin, cholecystokinin
Liver	Somatomedins, insulin-like growth factors

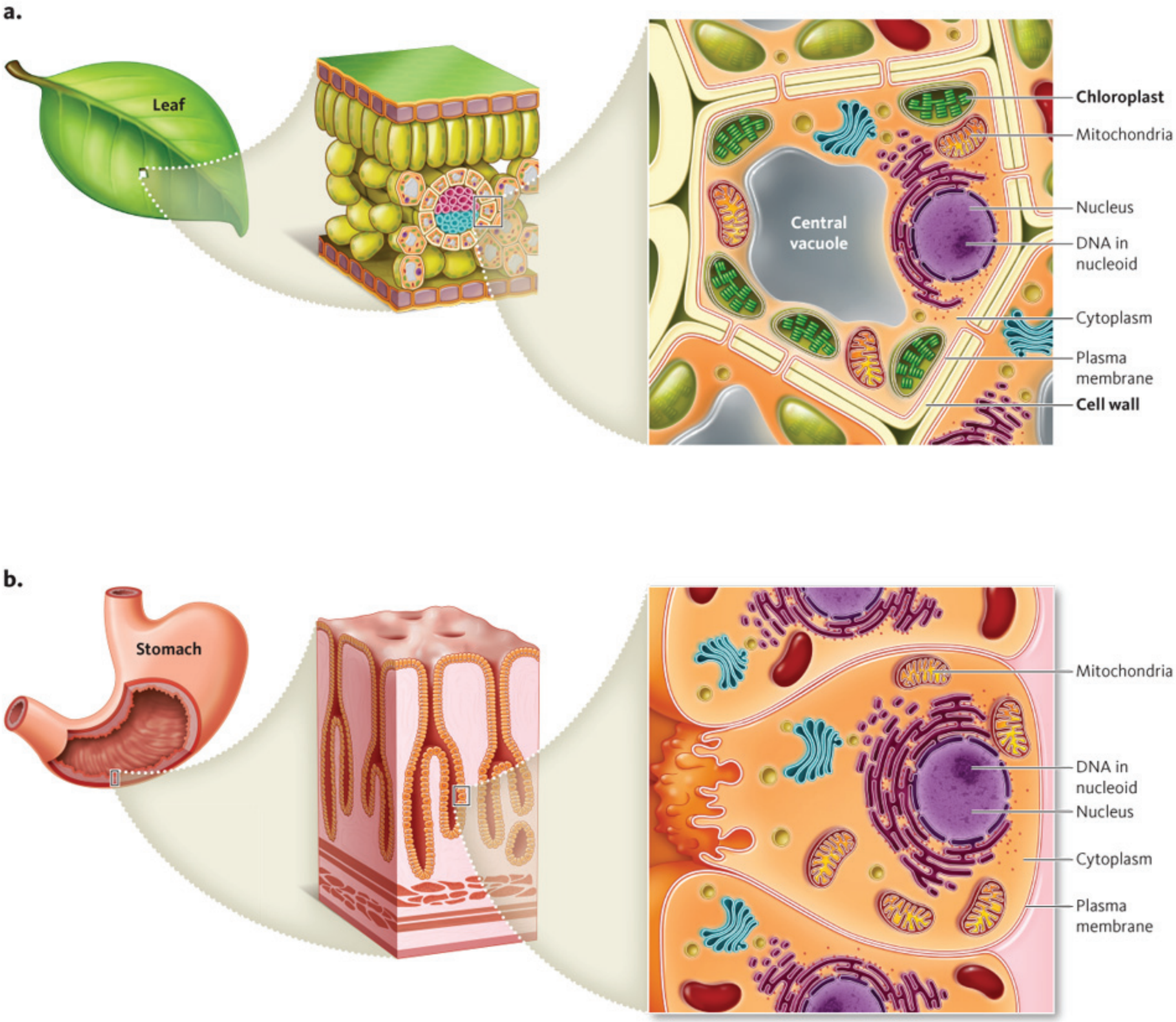


(A) Overview of the human auditory system
1 Sound waves travel through the auditory canal and vibrate the tympanic membrane.
Auditory canal
Outer ear
Middle ear
Eustation tube
Inner ear
Pinna
(B) The middle and inner ear
2 The ossicles transmit vibrations of the tympanic membrane to the oval window of the cochlea.
Semicircular canal of the vestibular system
3 Vibrations at the oval window create pressure waves in the fluid-filled cochlea.
Vestibulocochlear nerve
Ossicles
Stapes
Incus
Malleus
Vestibular nerve
Cochlear nerve
Cochlea
Tympanic membrane ("eardrum")
Preasure waves (in air)
Oval window (under stapes)
Round window
Eustachian tube
Preasure waves (in air)
(C) Cross section of the cochlea
Vestibular canal
Vestibular membrane
Cochlear canal
Basilar membrane
Tympanic canal
4 Pressure waves flex membranes separating the vestibular and tympanic canals.
Cochlear nerve
(D) The organ of Corti
Tectorial membrane
Organ of Corti
Basilar membrane
Stereocilia
Hair cell
Cochlear nerve
5 When basilar membrane is flexed, it bends stereocilia embedded in the overlaying tectorial membrane.
6 The movements of stereocilia are transduced into action potentials in the cochlear nerve.

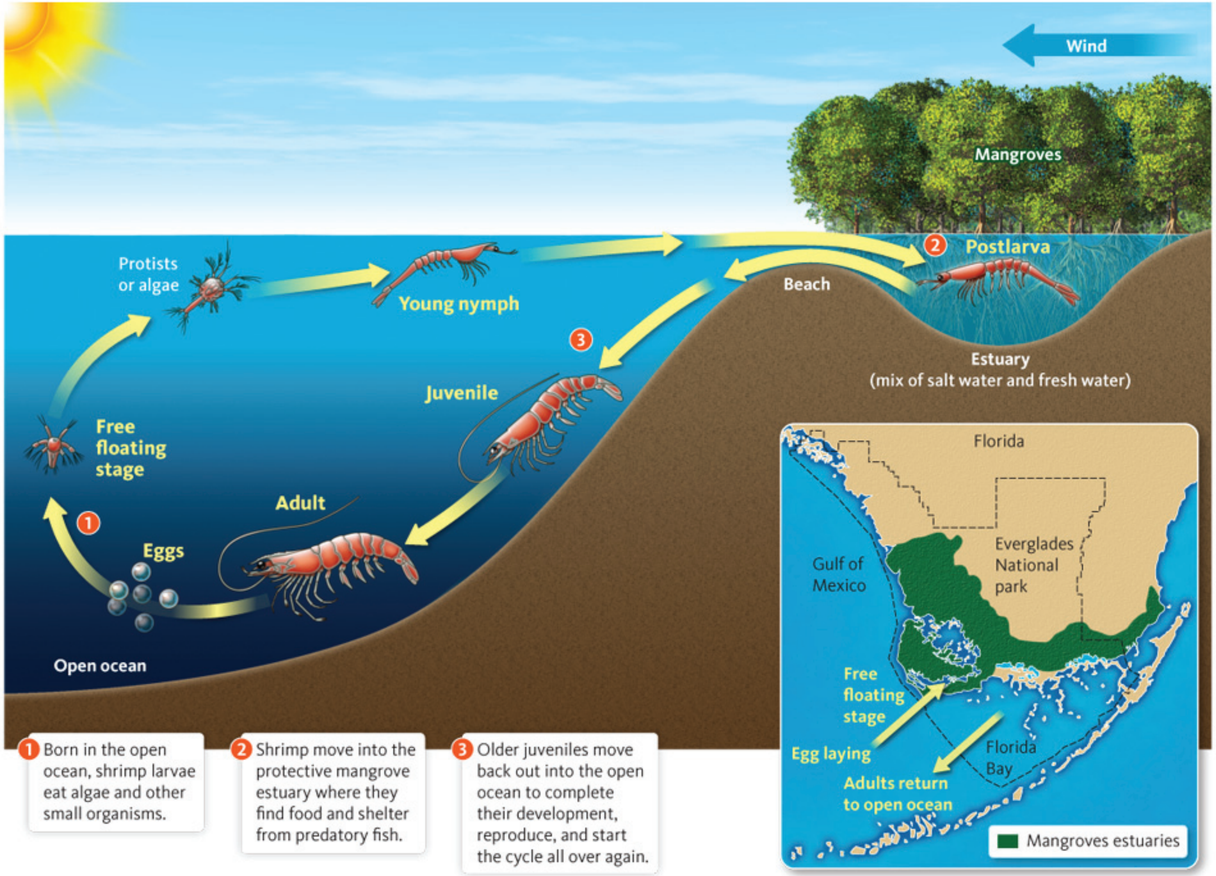

(A)
Humoral immune response
Activation phase
1 The antigen is taken up by phagocytosis and degraded in a lysosome.
Class II MHC protein
2 Interleukin-1 (a cytokine) activates a T_H cell.
Antigen
Macrophage
CD4
T cell receptor
T-helper cell (T_H)
3 A T cell receptor recognizes an antigenic fragment bound to a class II MHC protein on the macrophage.
4 Cytokines released by the T_H cell stimulate it to proliferate.
5 The T_H cell proliferates and forms a clone.
Effector phase
6 The binding of antigen to a specific IgM receptor triggers endocytosis, degradation, and display of the processed antigen.
7 A T cell receptor recognizes an antigenic fragment bound to a class II MHC protein on a B cell.
B cell
TH cell
8 Cytokines activate B cell proliferation.
9 B cells proliferate and differentiate.
10 The plasma cell produces antibodies.
Plasma cell
Memory cell
(B)
Cellular immune response
Activation phase
1 A viral protein made in an infected cell is degraded into fragments and picked up by a class I MHC protein.
Class I MHC protein
CD8
Antigen
Infected cell
Cytotoxic T cell (T_C)
T cell receptor
2 A T cell receptor recognizes an antigenic fragment bound to a class I MHC protein on an infected cell.
3 The T_C cell proliferates and forms a clone.
Effector phase
4 A T cell receptor again recognizes an antigenic fragment bound to a class I MHC protein.
Infected cell (one of many)
5 The T cell releases perforin…
6 …which results in apoptosis of the infected cell before the viruses can multiply.



Eukaroyte
Prokaroyte
10 μm
Flagellum
Nucleolus
Ribosomes
Nucleus
Nucleoid
Capsule
Cell wall
Cell
membrane
Mitochondrion



a.
Leaf
Central vacuole
Chloroplast
Mitochondria
Nucleus
DNA in nucleoid
Cytoplasm
Plasma membrane
Cell wall
b.
Stomach
Mitochondria
DNA in nucleoid
Nucleus
Cytoplasm
Plasma membrane



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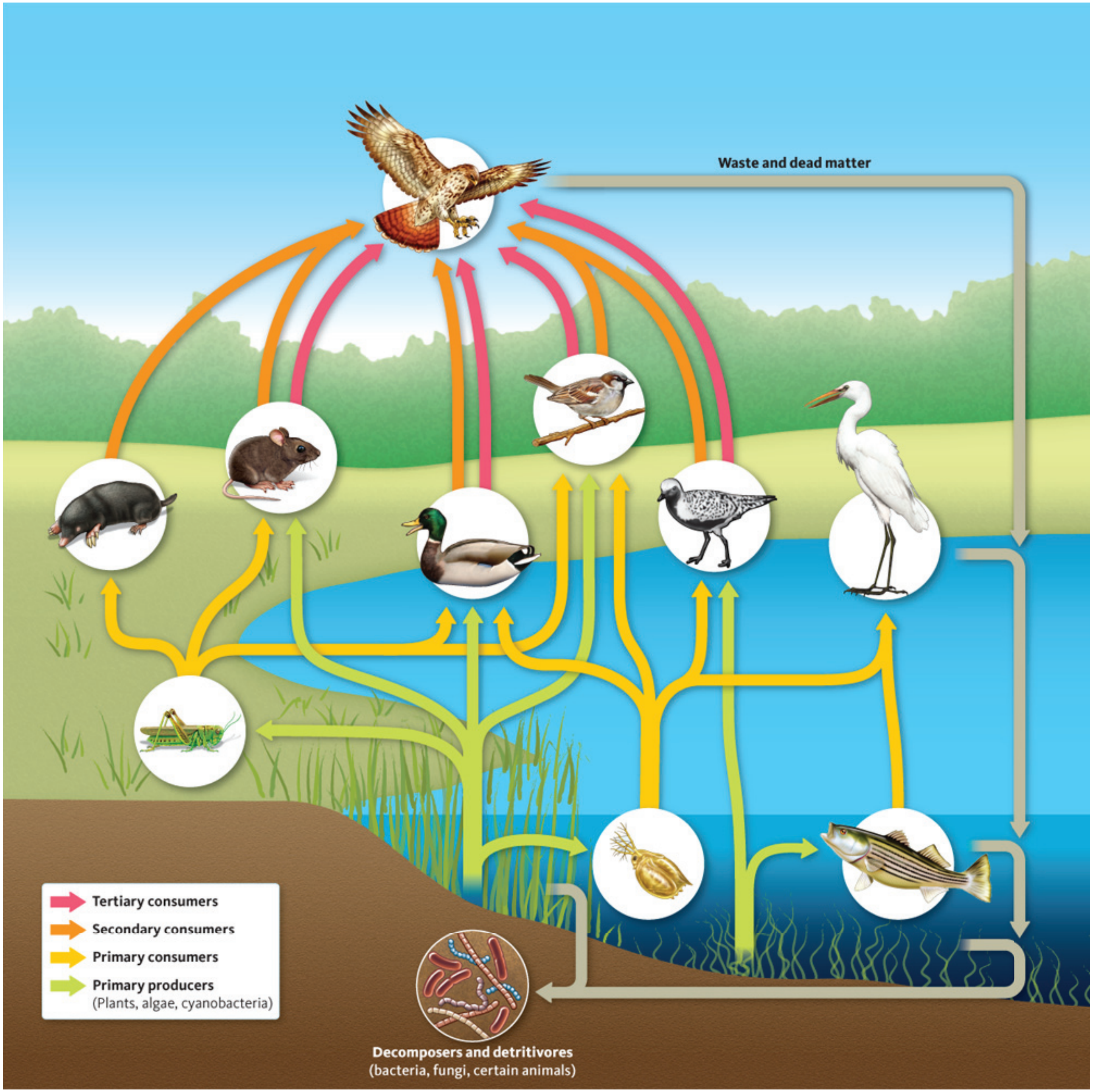

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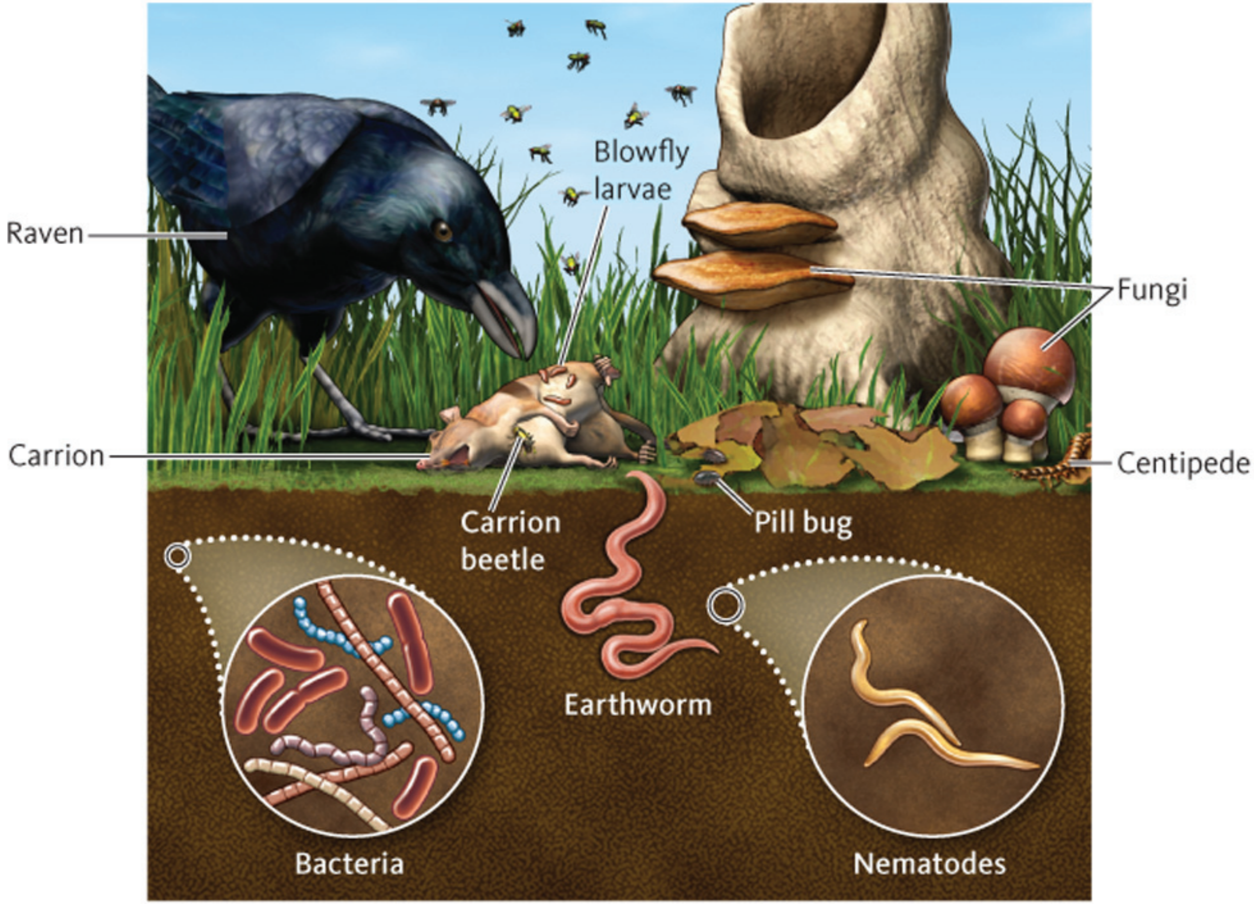

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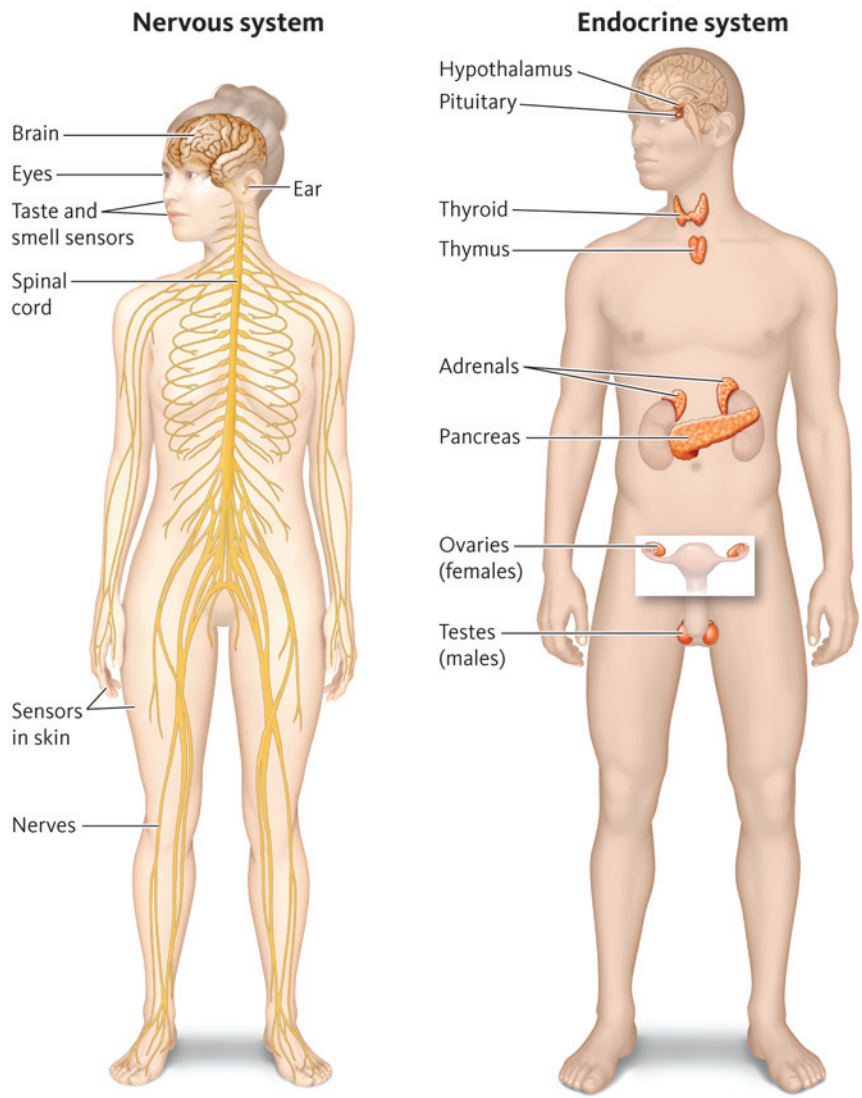
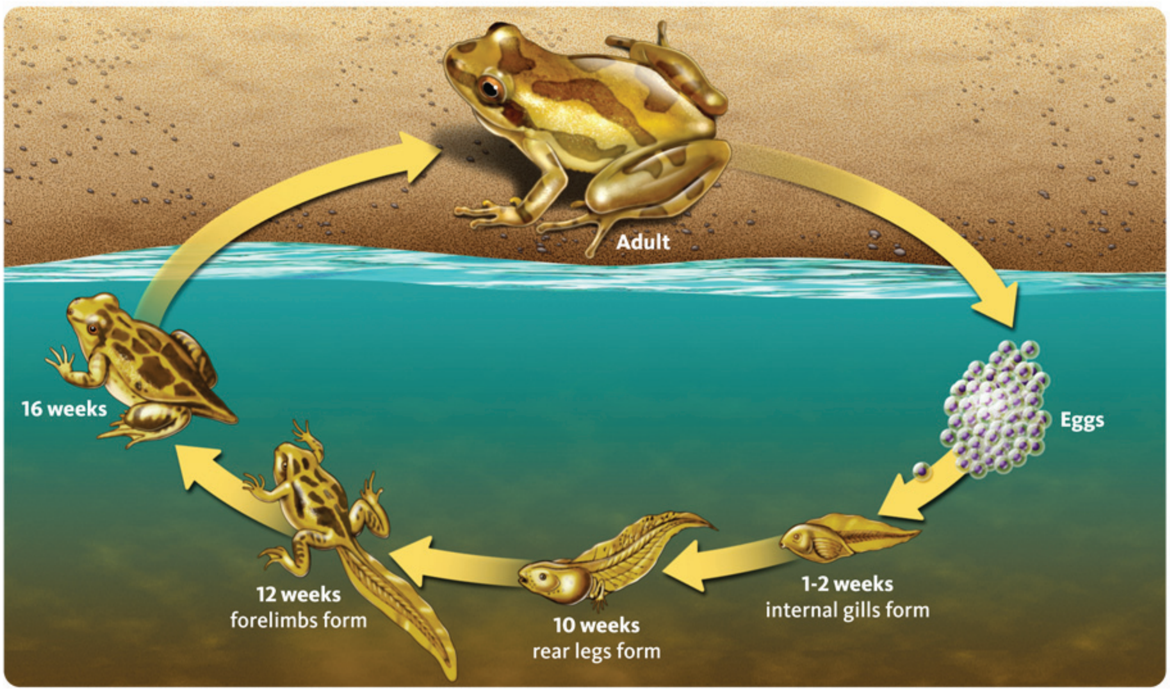


Nervous system
Brain
Eyes
Taste and smell sensors
Spinal cord
Ear
Sensors in skin
Nerves
Endocrine system
Hypothalamus
Pituitary
Thyroid
Thymus
Adrenals
Pancreas
Ovaries (females)
Testes (males)



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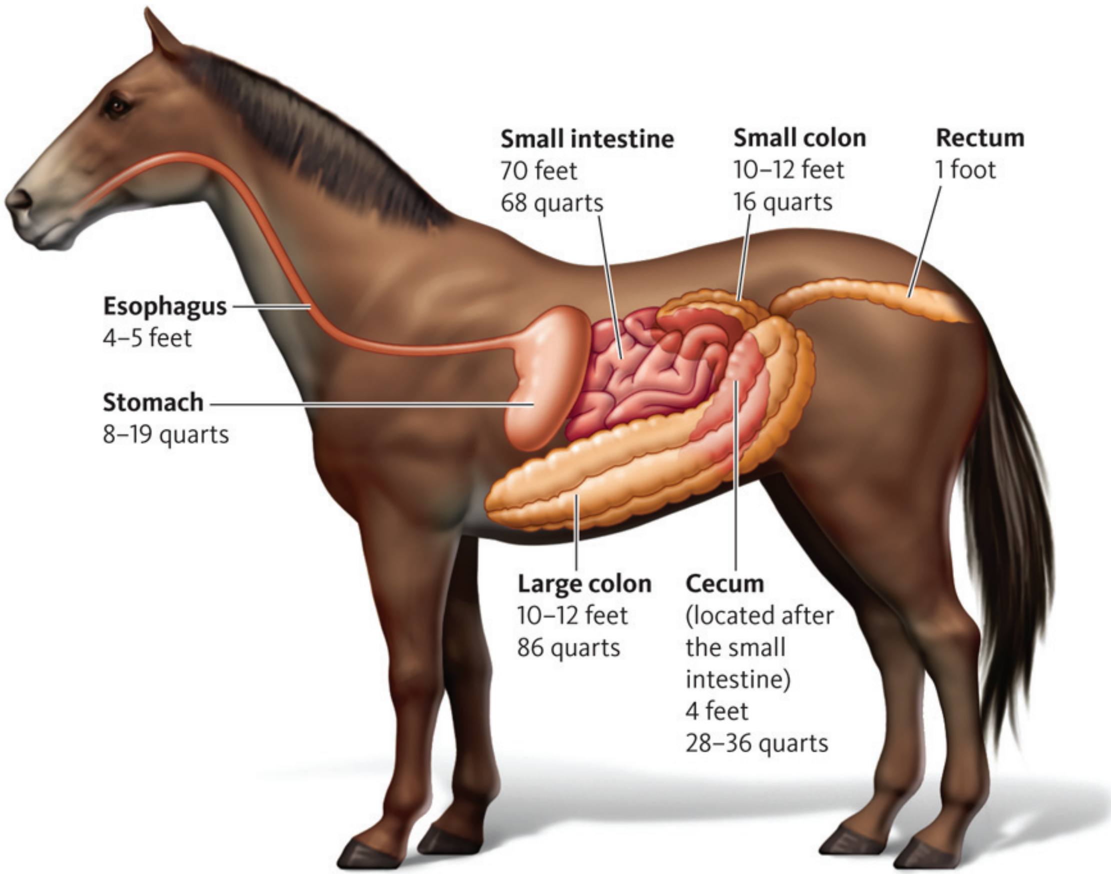

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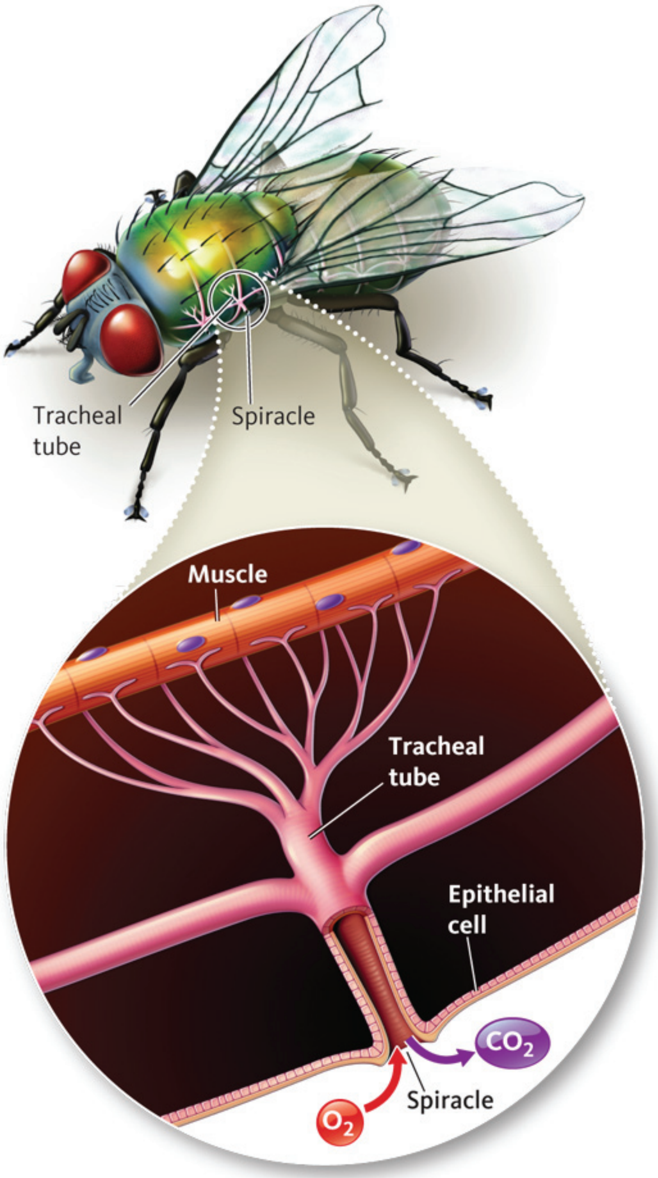

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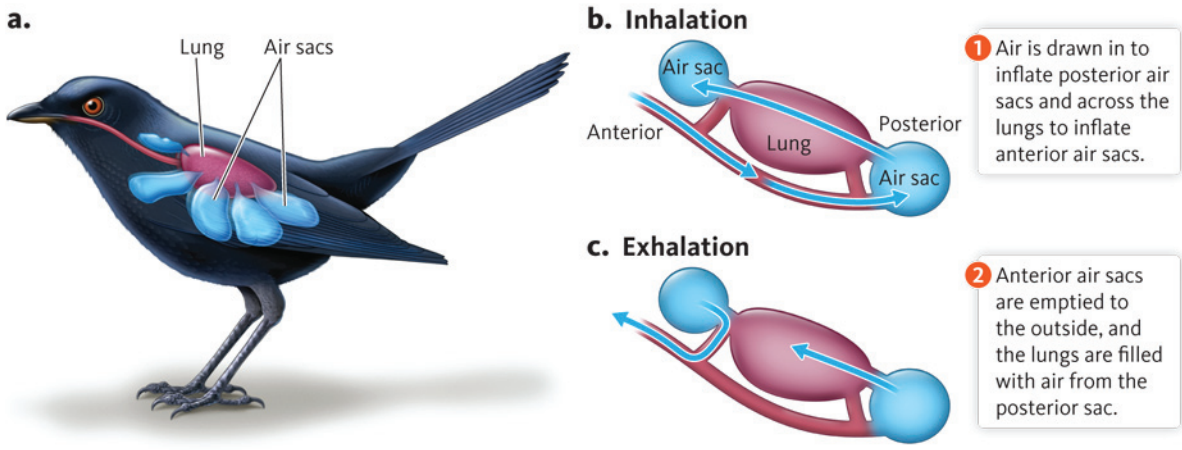
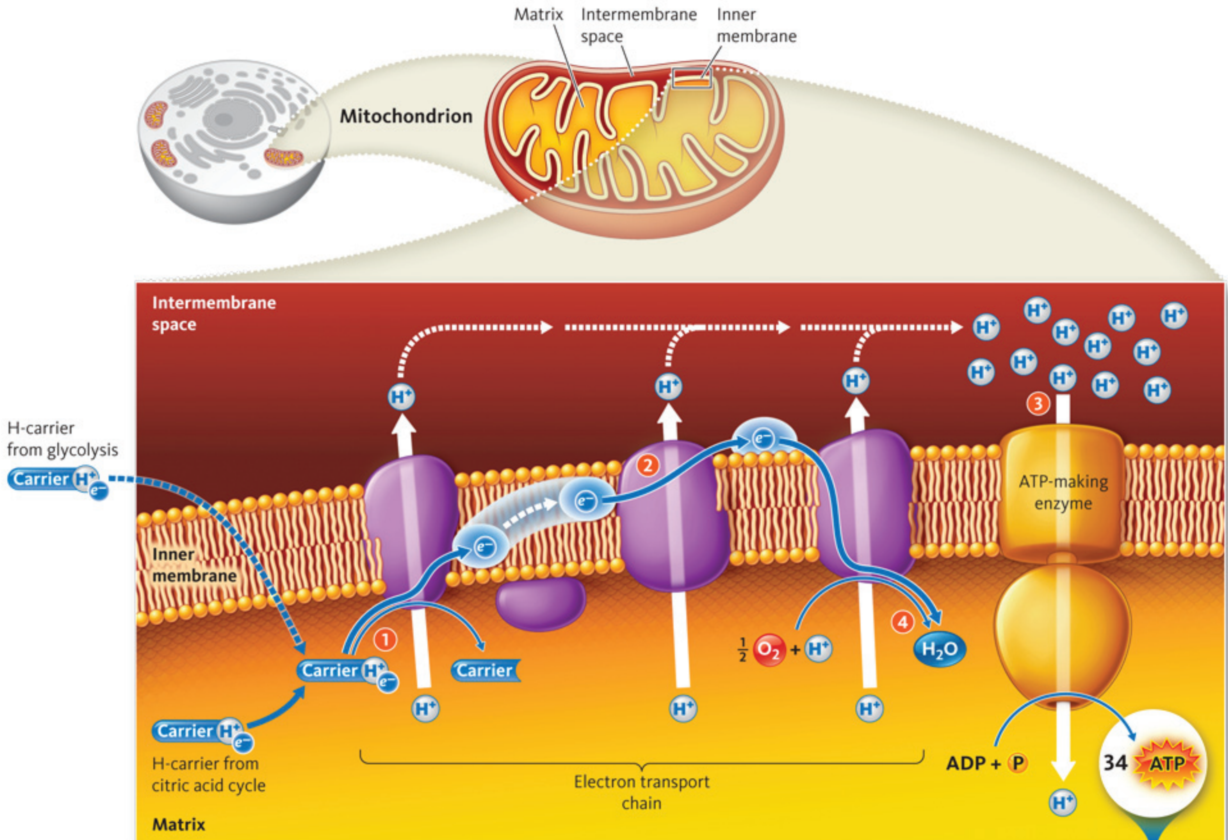

a.
Lung
Air sacs
b. Inhalation
Air sac
Anterior
Lung
Posterior
Air sac
1 Air is drawn in to inflate posterior air sacs and across the lungs to inflate anterior air sacs.
c. Exhalation
2 Anterior air sacs are emptied to the outside, and the lungs are filled with air from the posterior sac.

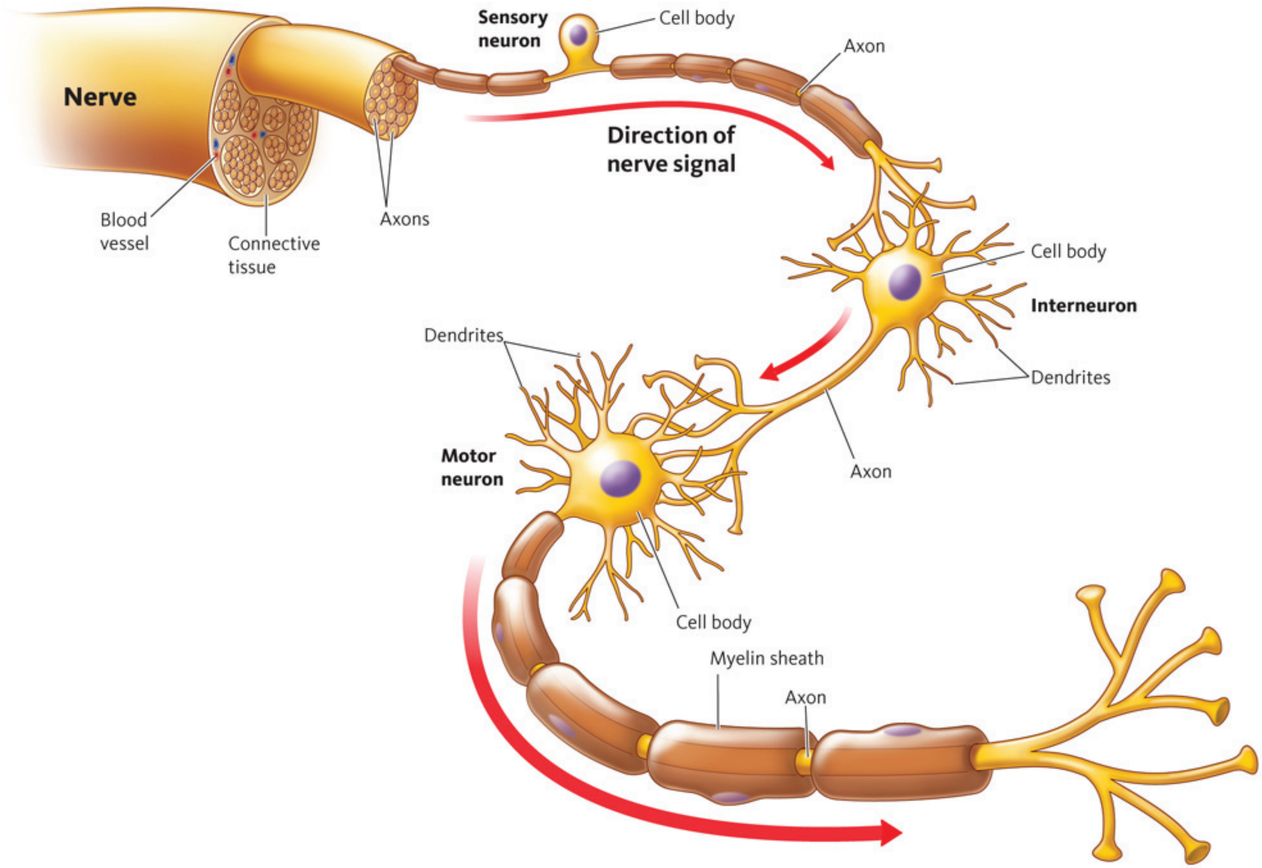


1 Carrier molecules release the hydrogen atoms at the inner mitochondrial membrane. In this stage, hydrogen atoms are split into electrons and protons (H^+), which go their separate ways.

2 The electrons pass along a chain of large proteins, or the electron transport chain, located in the inner membrane of the mitochondria. As they are passed, they release small amounts of their energy. This energy is then used to move and concentrate the protons on one side of the mitochondrial membrane.

3 The electron transport chain separates the positive and negative charges creating a steep concentration gradient. The concentrated protons then move down the gradient through a large enzyme that channels the energy to make a large number of ATP molecules.

4 Oxygen enters metabolism at the very last step in the process and links the movement of the electrons and protons together to form water.



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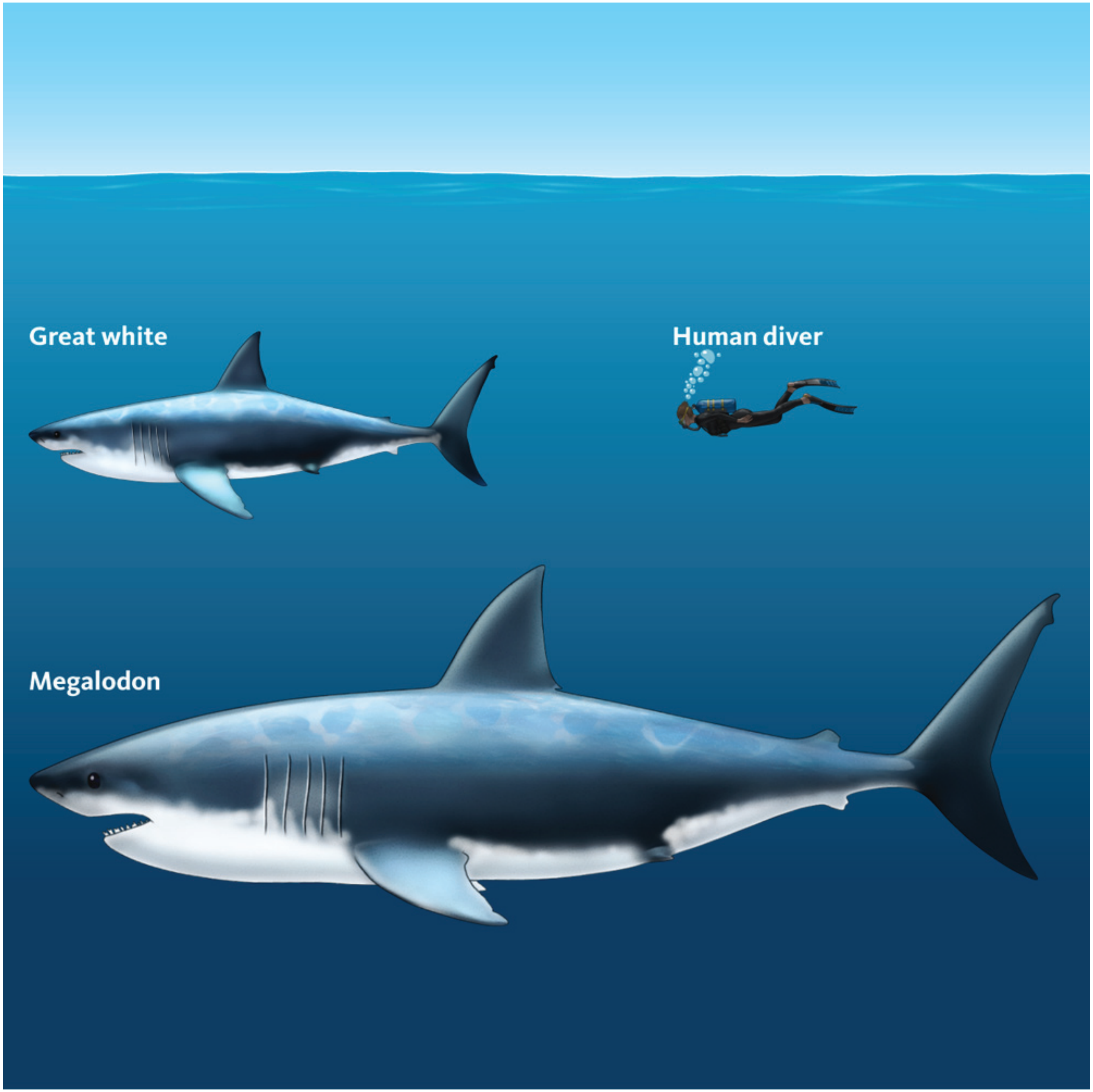

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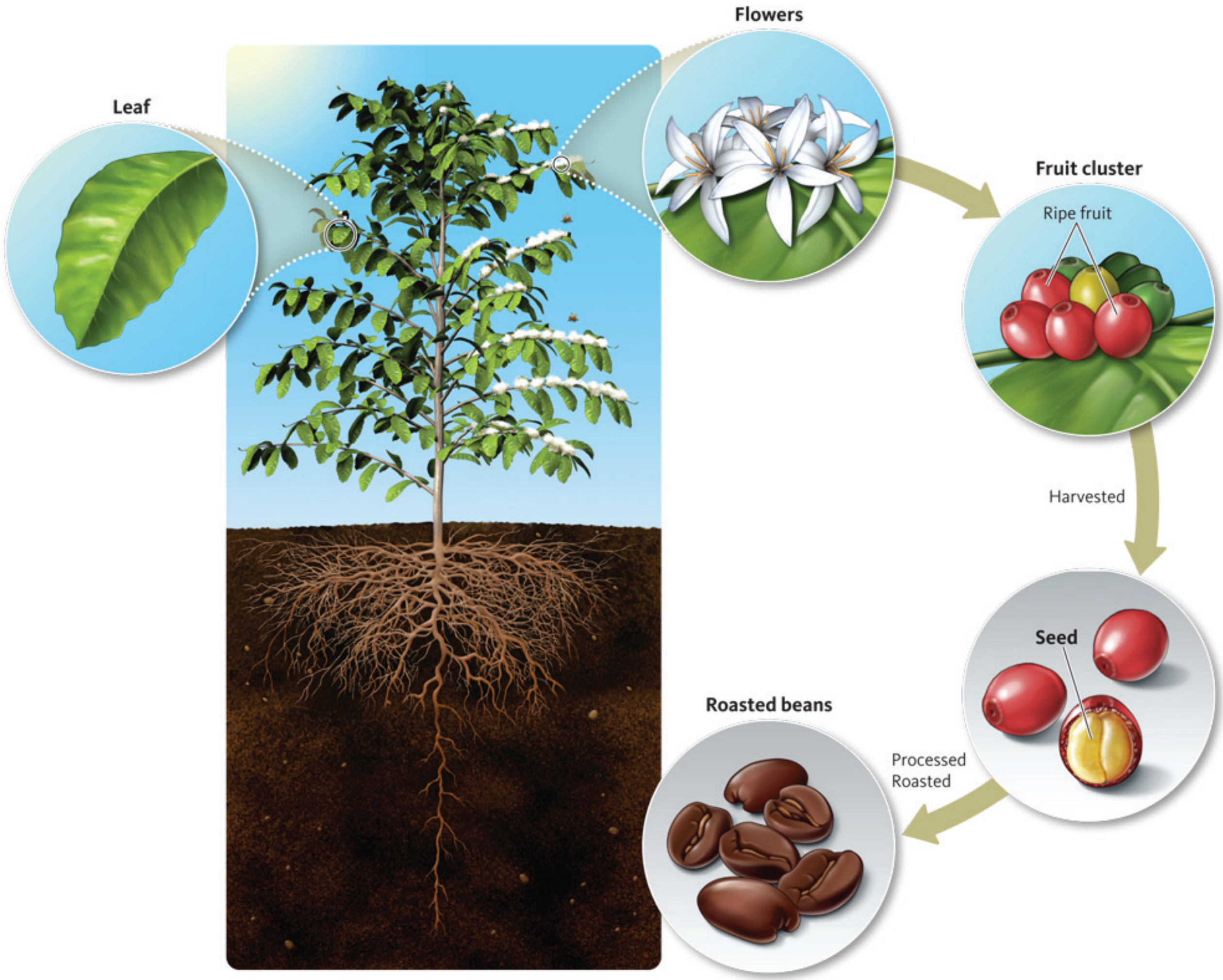

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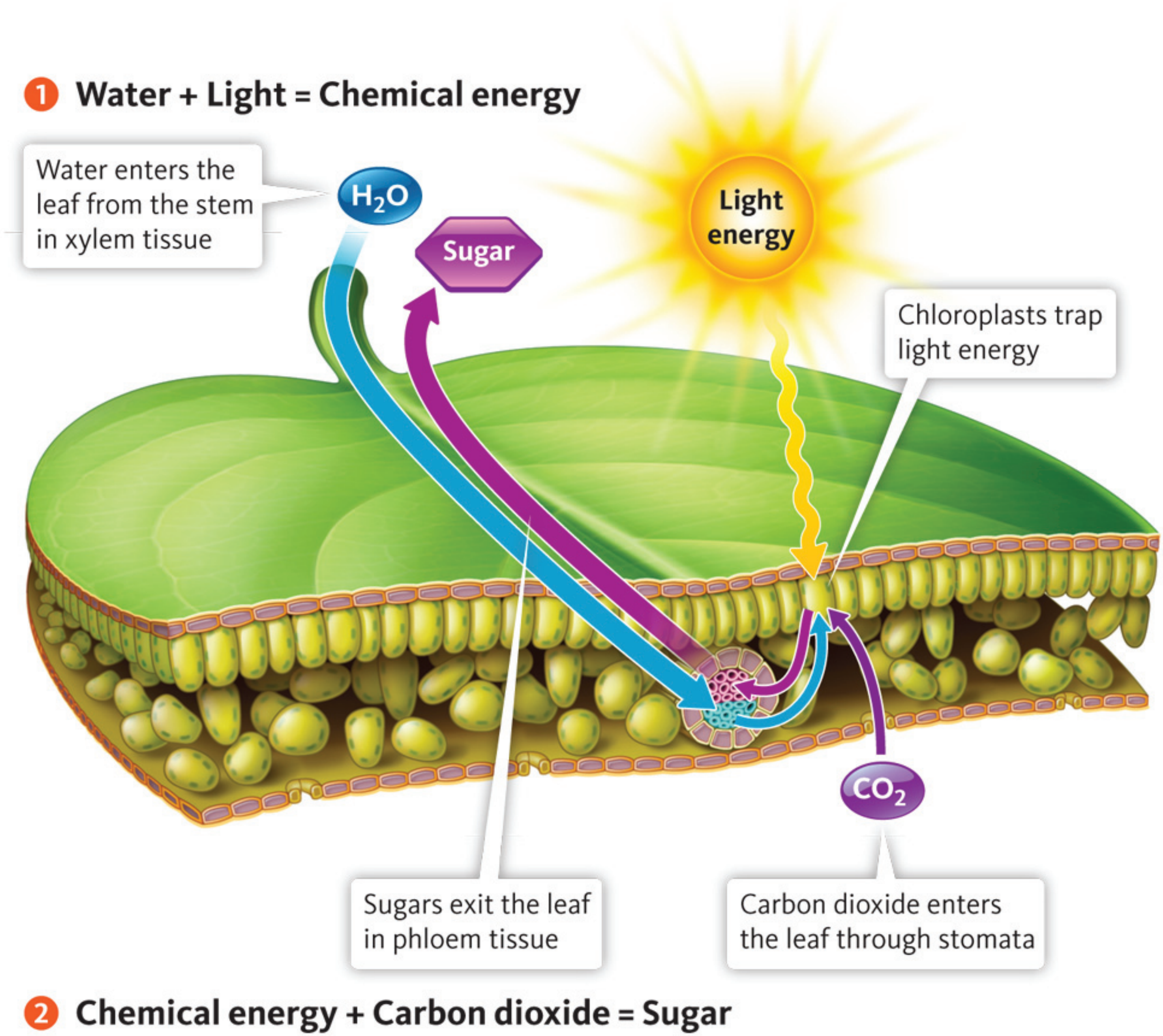
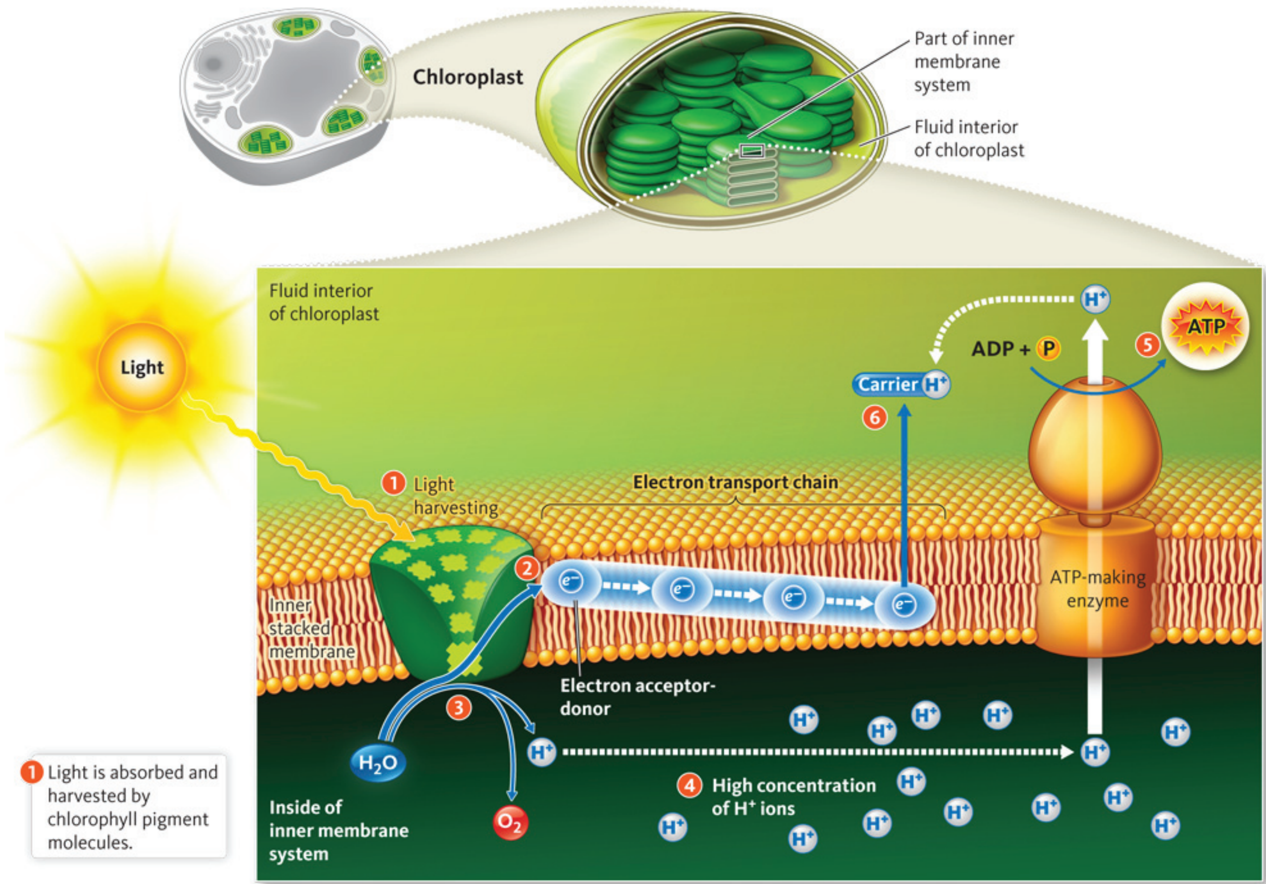

1 Water + Light = Chemical energy
Water enters the leaf from the stem in xylem tissue
H_2O
Sugar
Light energy
Chloroplasts trap light energy
CO_2
Sugars exit the leaf in phloem tissue
Carbon dioxide enters the leaf through stomata
2 Chemical energy + Carbon dioxide = Sugar



1 Light is absorbed and harvested by chlorophyll pigment molecules.

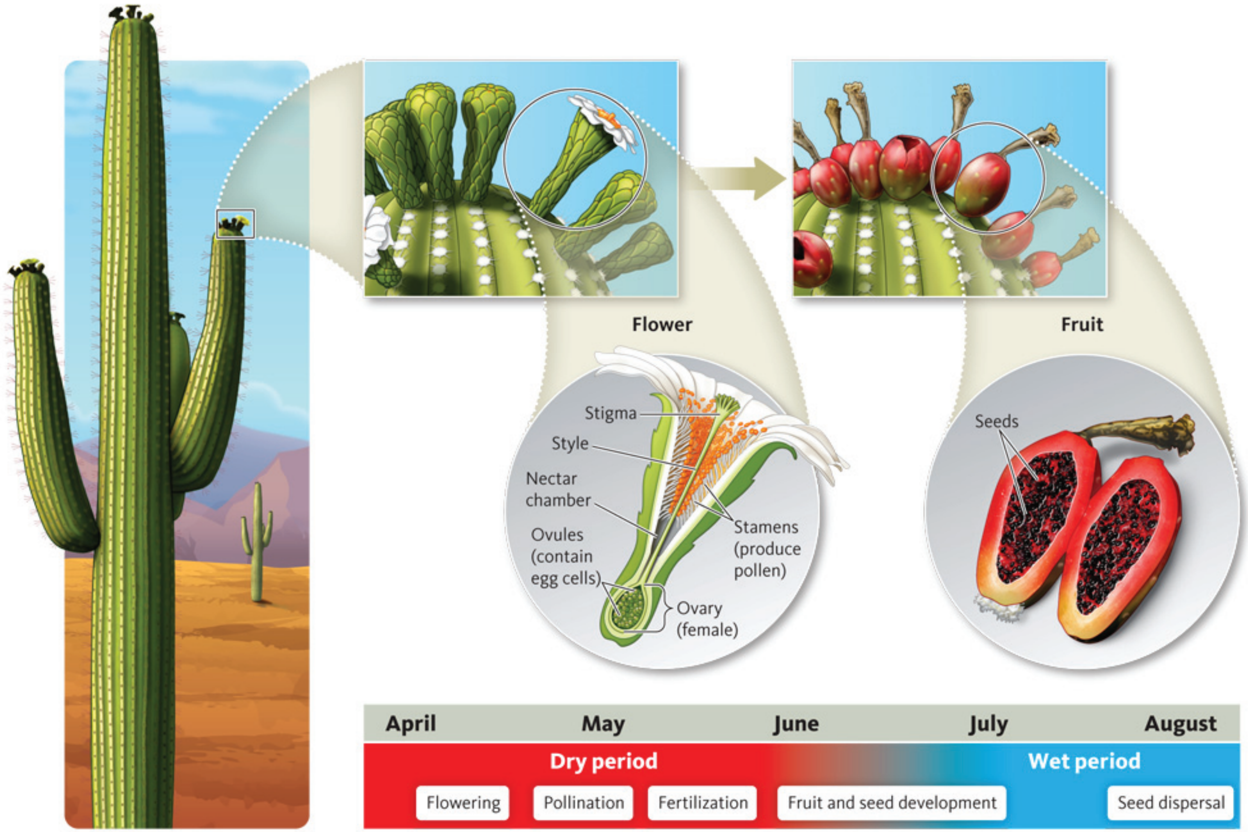
2 The energy absorbed from light is used to strip an electron from one chlorophyll. The electron then enters the electron transport chain.

3 Simultaneously, a water molecule is split into three components, an electron, which is donated back to the chlorophyll,...

4 ...hydrogen (H^+) ions which get concentrated inside the membrane complex, and oxygen–a waste product that diffuses out of the plant and into the atmosphere.

5 The two products of this set of reactions are ATP...

6 ...and a hydrogen carrier molecule, both of which are used in the second stage of photosynthesis.



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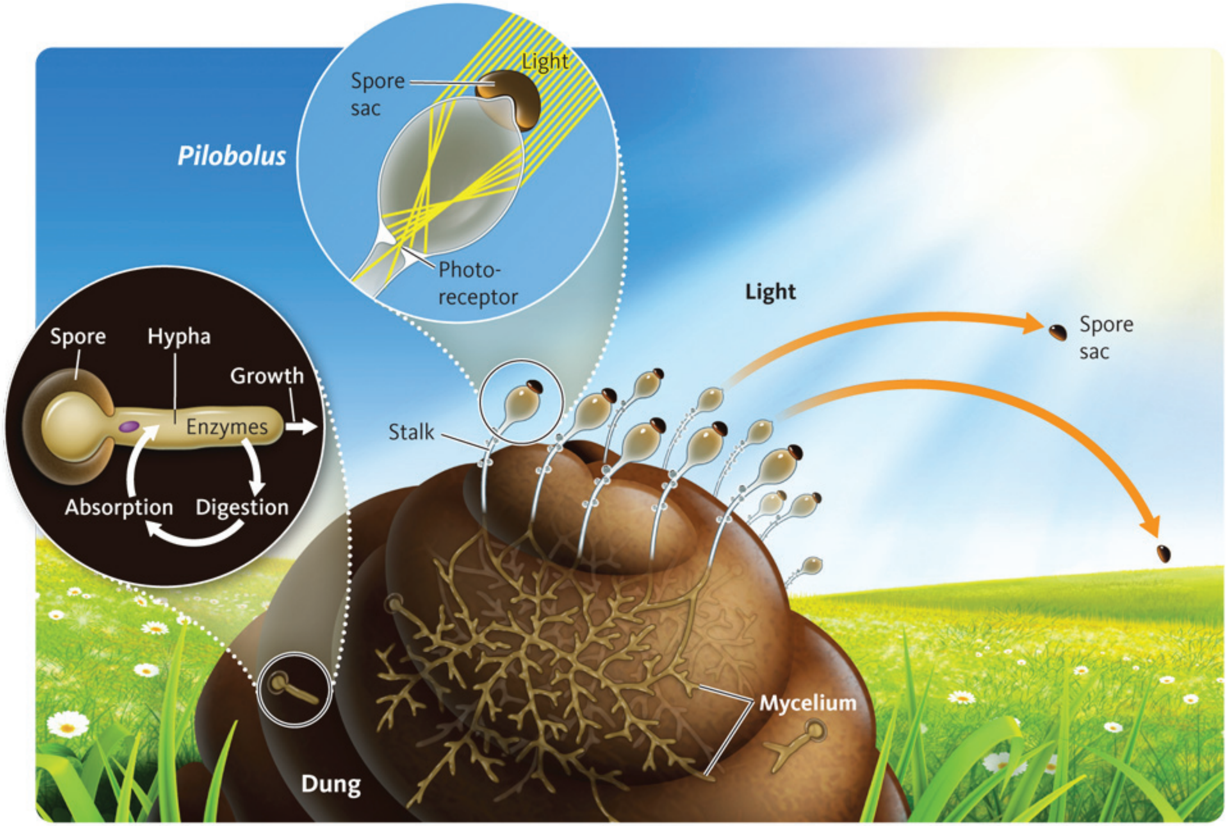
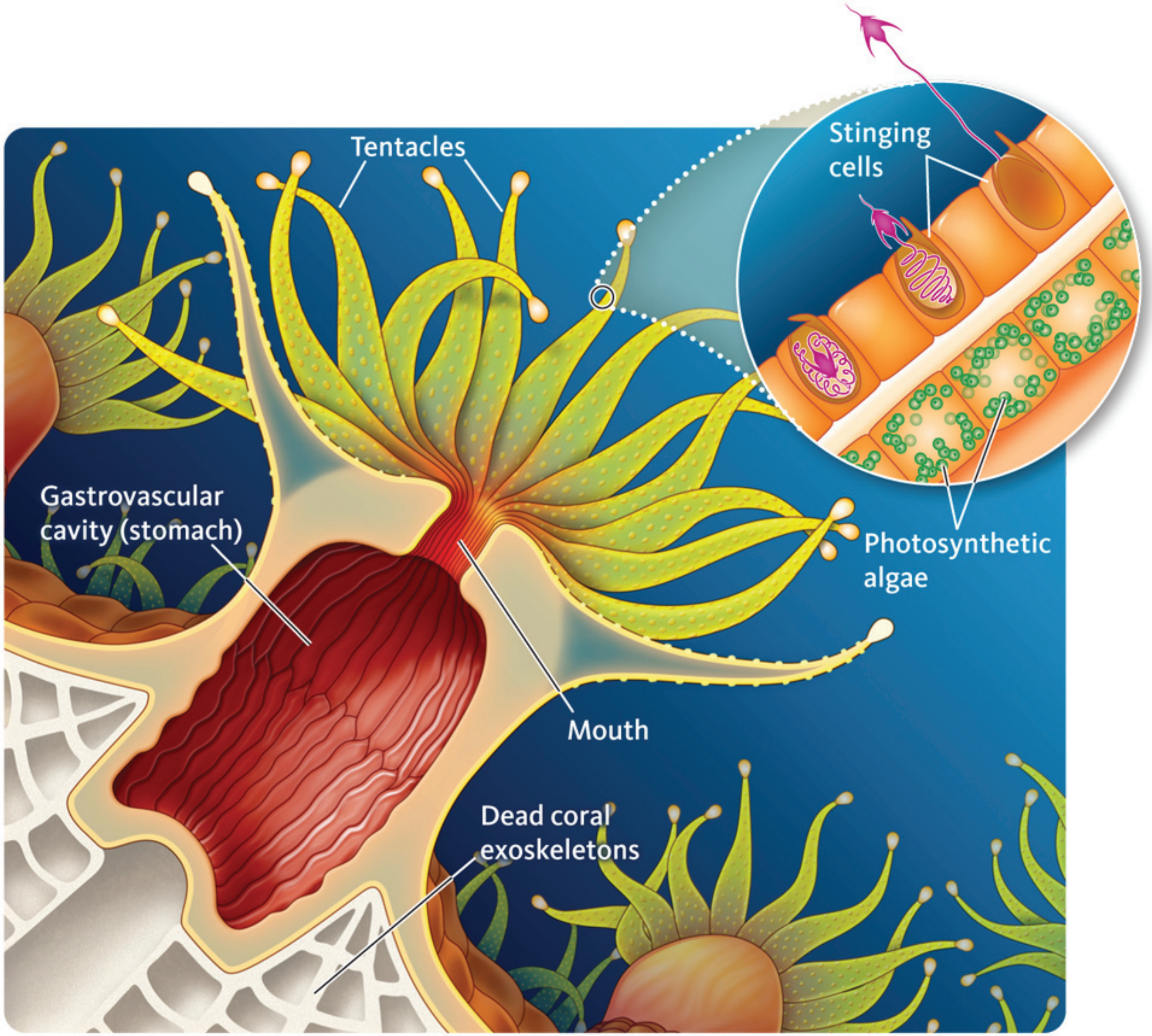


Pilobolus
Spore
sac
Light
Photo-
receptor
Spore
Hypha
Growth
Enzymes
Absorption
Digestion
Light
Spore
sac
Stalk
Mycelium
Dung



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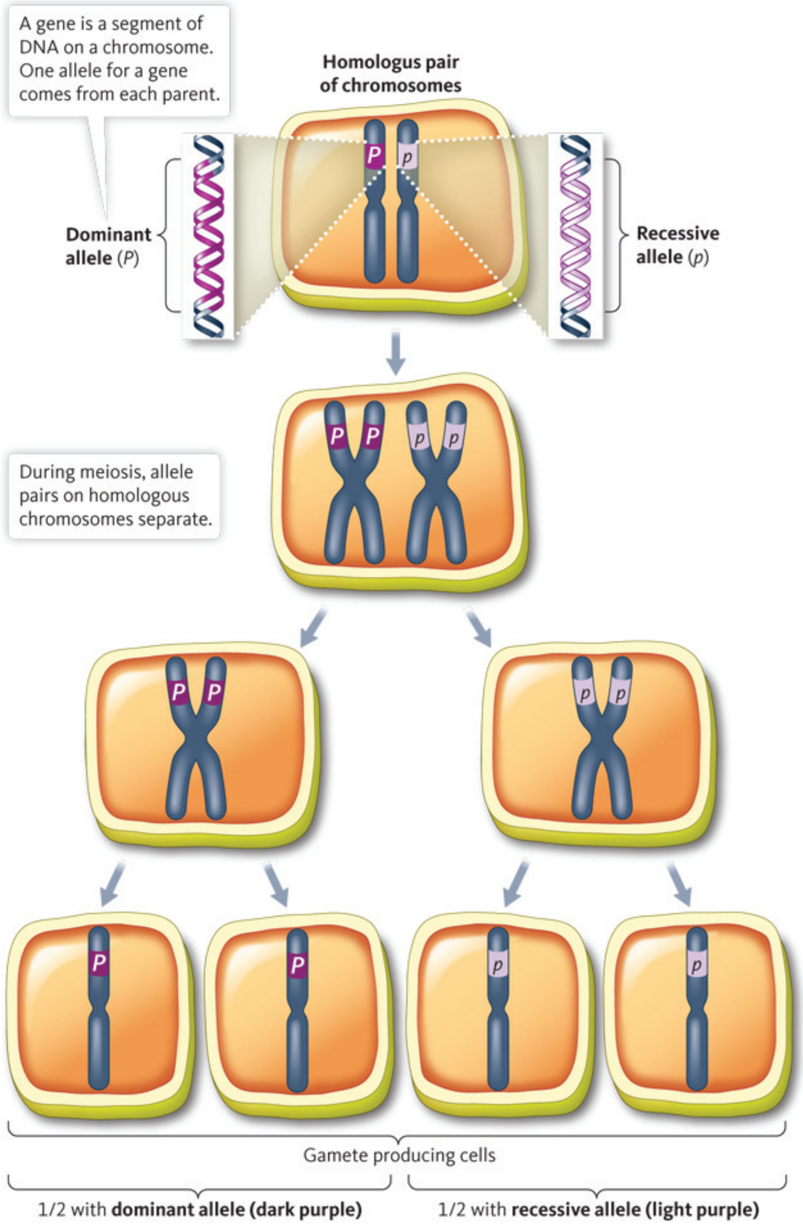
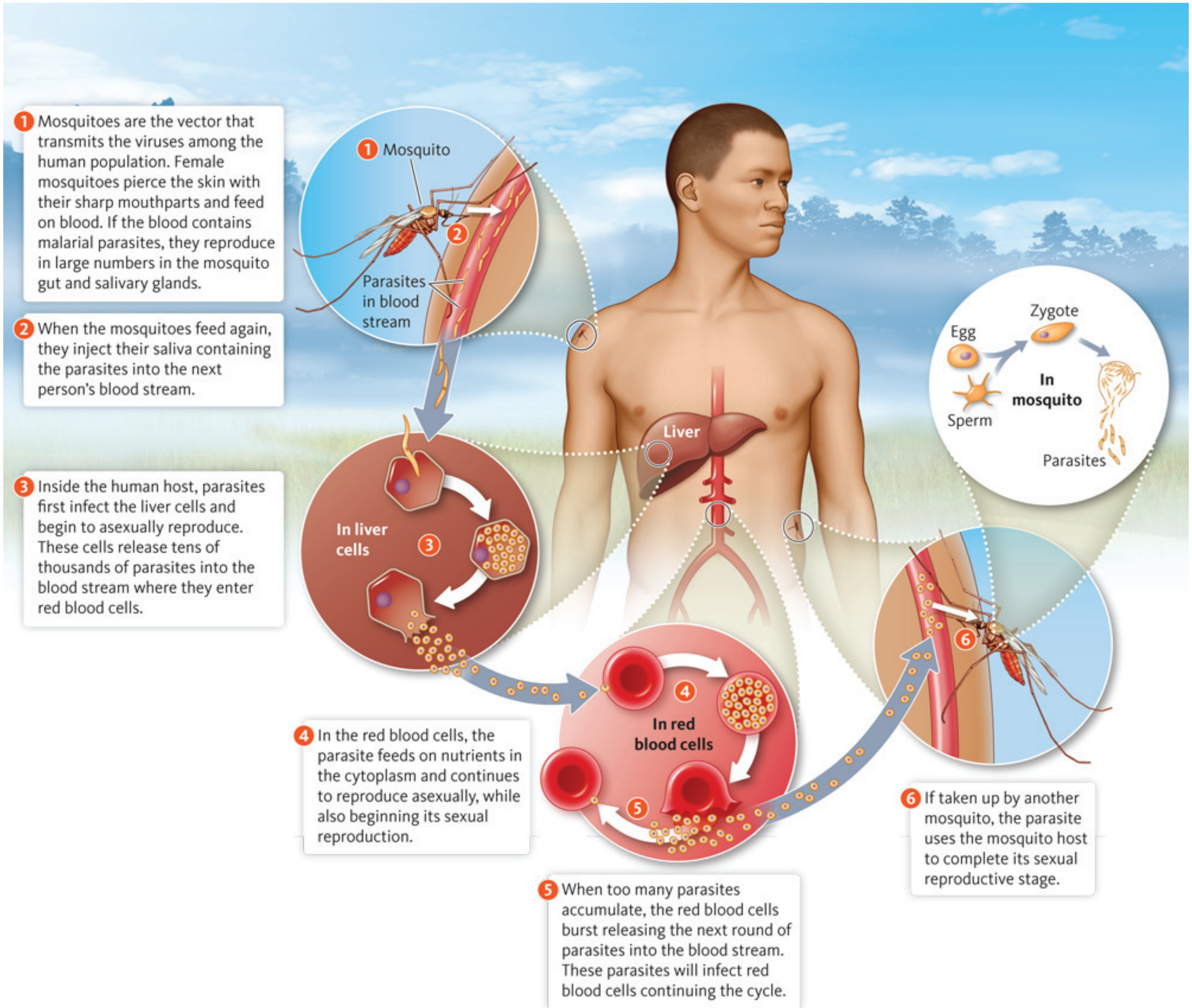

A gene is a segment of DNA on a chromosome. One allele for a gene comes from each parent.
Homologus pair of chromosomes
Dominant allele (P)
Recessive allele (p)
During meiosis, allele pairs on homologous chromosomes separate.
Gamete producing cells
1/2 with dominant allele (dark purple)
1/2 with recessive allele (light purple)



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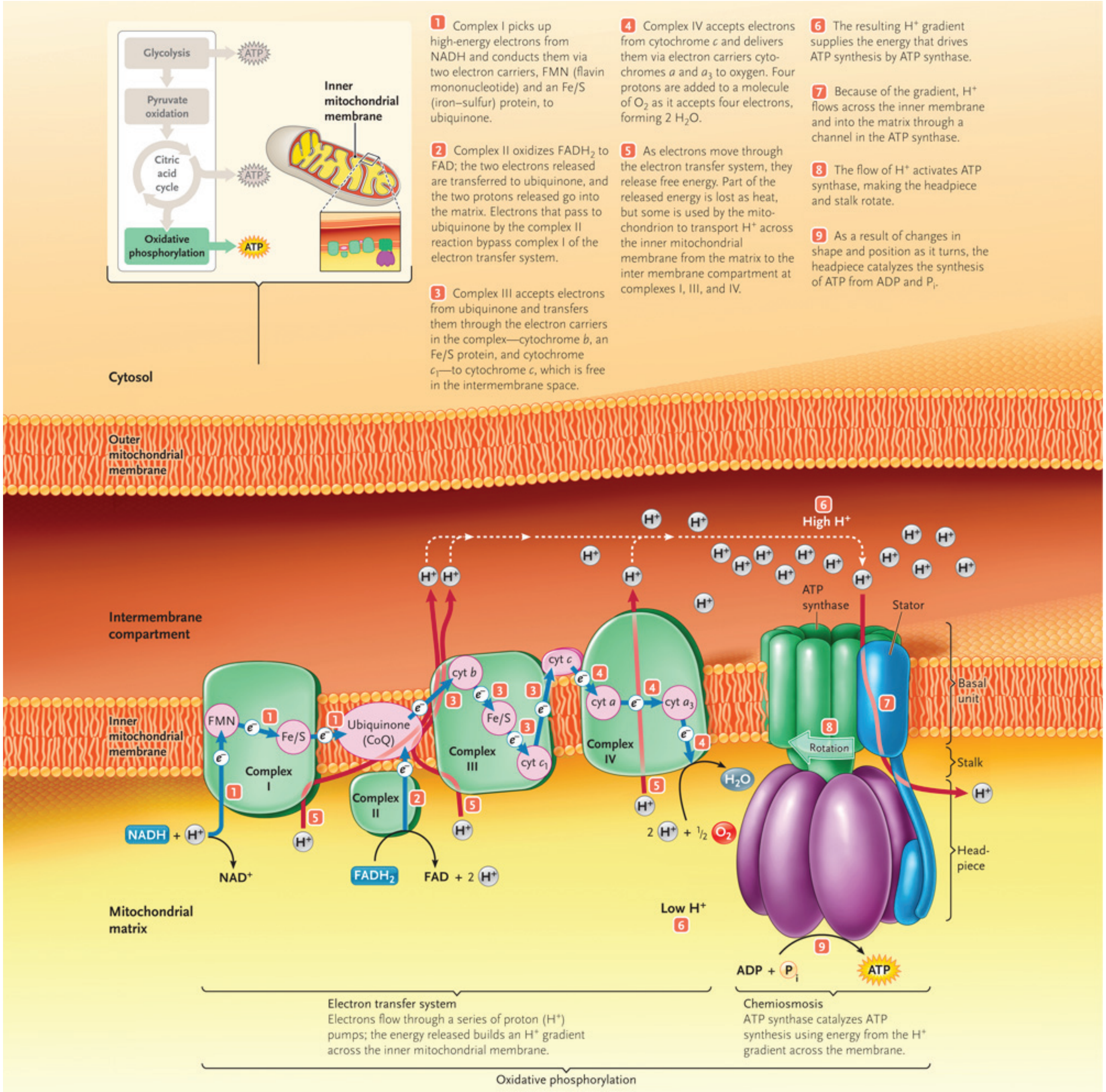
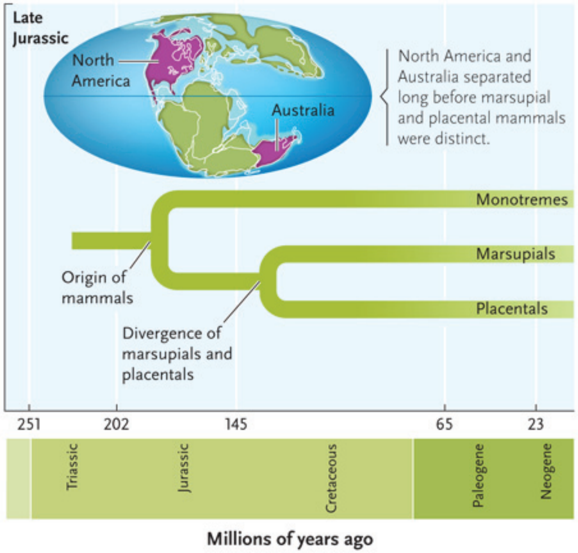
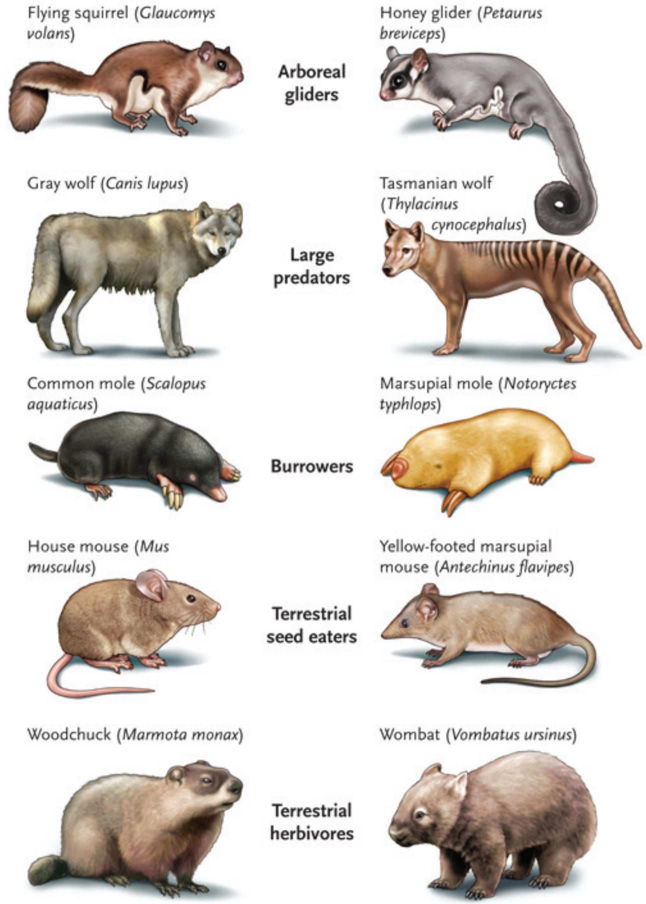


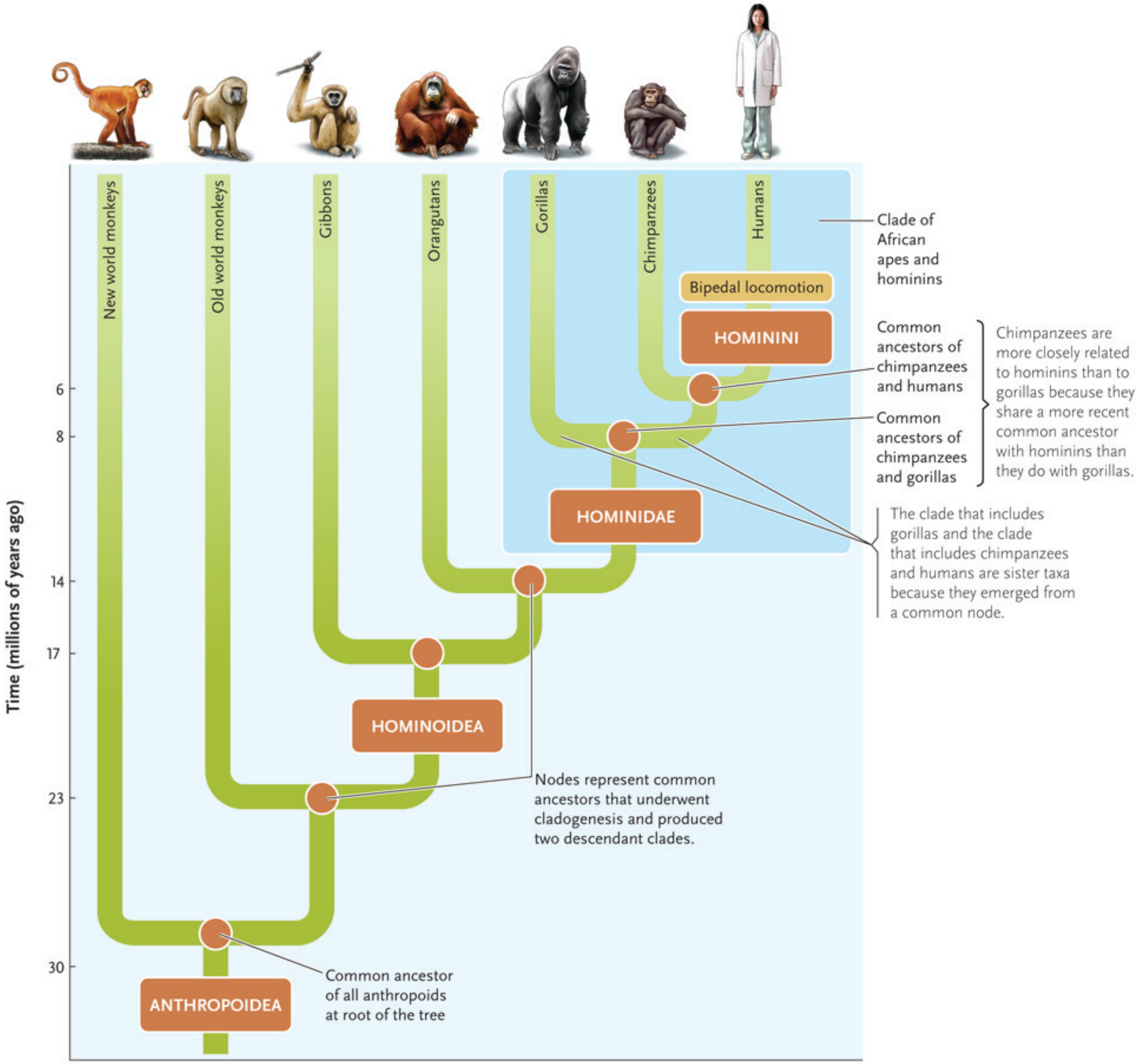
Glycolysis
ATP
Pyruvate oxidation
Citric acid cycle
ATP
Oxidative phosphorylation
ATP
Inner mitochondrial membrane
1 Complex I picks up high-energy electrons from NADH and conducts them via two electron carriers, FMN (flavin mononucleotide) and an Fe/S (iron–sulfur) protein, to ubiquinone.
2 Complex II oxidizes $FADH_2$ to FAD; the two electrons released are transferred to ubiquinone, and the two protons released go into the matrix. Electrons that pass to ubiquinone by the complex II reaction bypass complex I of the electron transfer system.
3 Complex III accepts electrons from ubiquinone and transfers them through the electron carriers in the complex—cytochrome *b*, an Fe/S protein, and cytochrome c_1—to cytochrome *c*, which is free in the intermembrane space.
4 Complex IV accepts electrons from cytochrome *c* and delivers them via electron carriers cytochromes *a* and a_3 to oxygen. Four protons are added to a molecule of O_2 as it accepts four electrons, forming 2 H_2O.
5 As electrons move through the electron transfer system, they release free energy. Part of the released energy is lost as heat, but some is used by the mitochondrion to transport H^+ across the inner mitochondrial membrane from the matrix to the inter membrane compartment at complexes I, III, and IV.
6 The resulting H^+ gradient supplies the energy that drives ATP synthesis by ATP synthase.
7 Because of the gradient, H^+ flows across the inner membrane and into the matrix through a channel in the ATP synthase.
8 The flow of H^+ activates ATP synthase, making the headpiece and stalk rotate.
9 As a result of changes in shape and position as it turns, the headpiece catalyzes the synthesis of ATP from ADP and P_i.
Cytosol
Outer mitochondrial membrane
Intermembrane compartment
Inner mitochondrial membrane
Mitochondrial matrix
6 High H^+
ATP synthase
Stator
Basal unit
Stalk
Head-piece
Rotation
FMN
Fe/S
Ubiquinone (CoQ)
Complex I
Complex II
cyt *b*
Fe/S
Complex III
cyt c_1
cyt *c*
cyt *a*
cyt a_3
Complex IV
H_2O
2 H^+ + ½ O_2
NADH + H^+
NAD^+
$FADH_2$
FAD + 2 H^+
Low H^+
ADP + P_i
ATP
Electron transfer system
Electrons flow through a series of proton (H^+) pumps; the energy released builds an H^+ gradient across the inner mitochondrial membrane.
Chemiosmosis
ATP synthase catalyzes ATP synthesis using energy from the H^+ gradient across the membrane.
Oxidative phosphorylation

A. Mammals and continental drift



B. Convergence of marsupials and placentals





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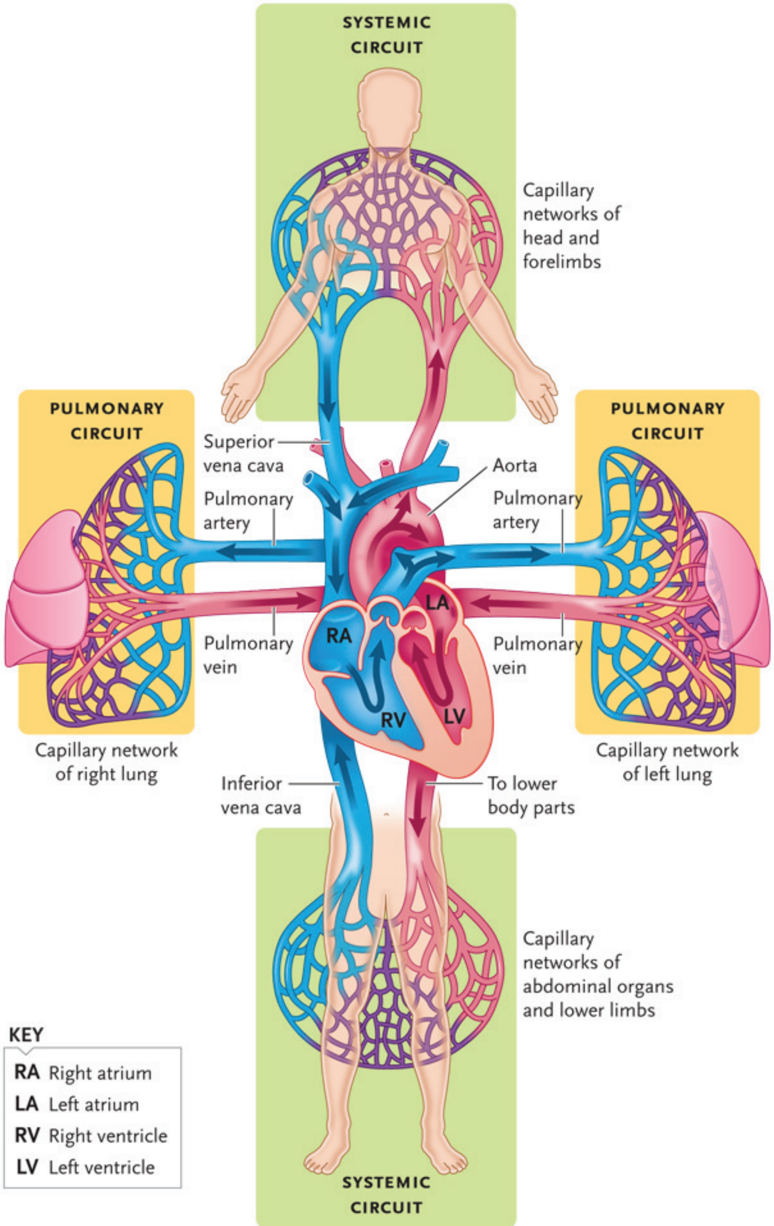
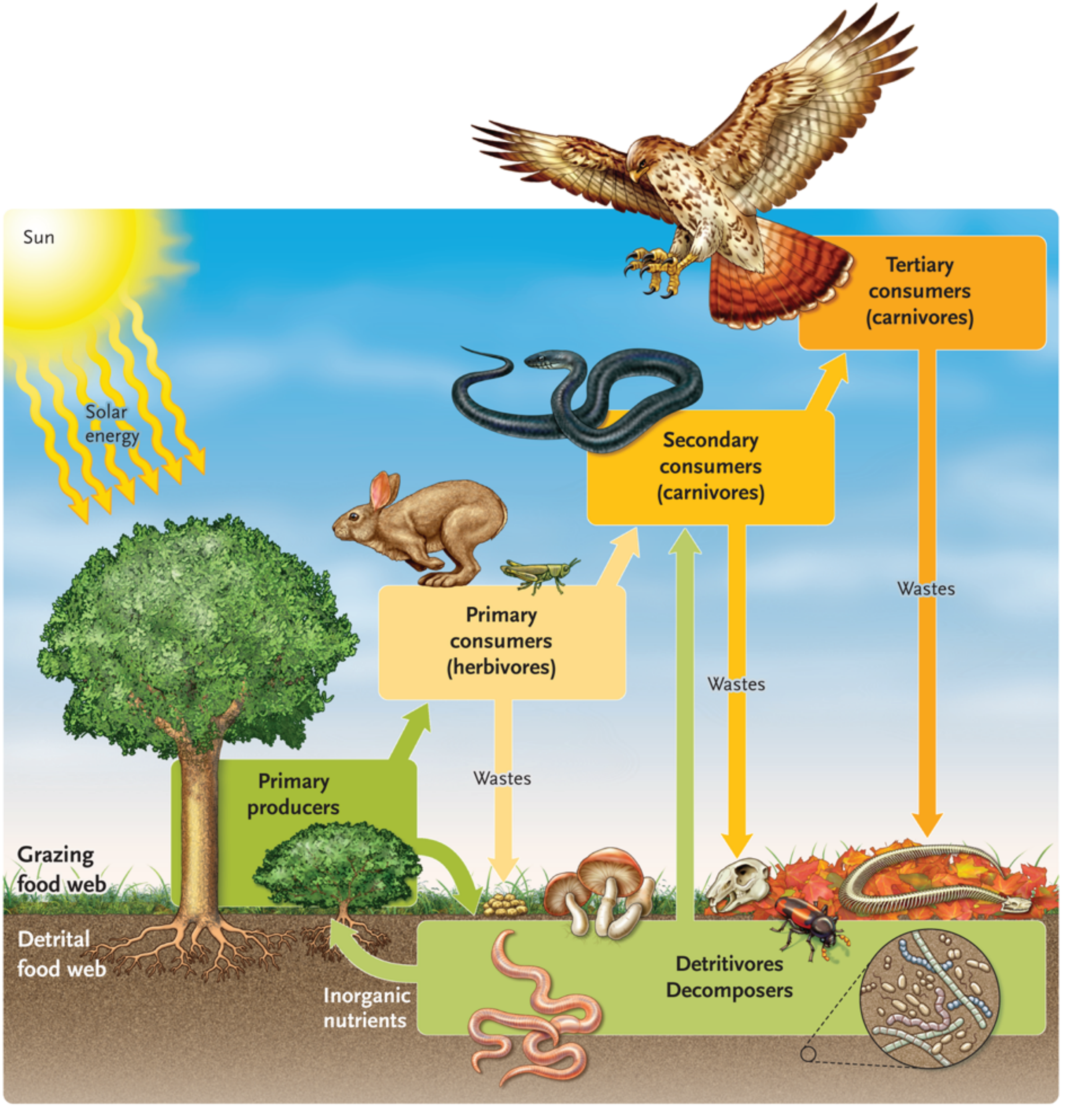
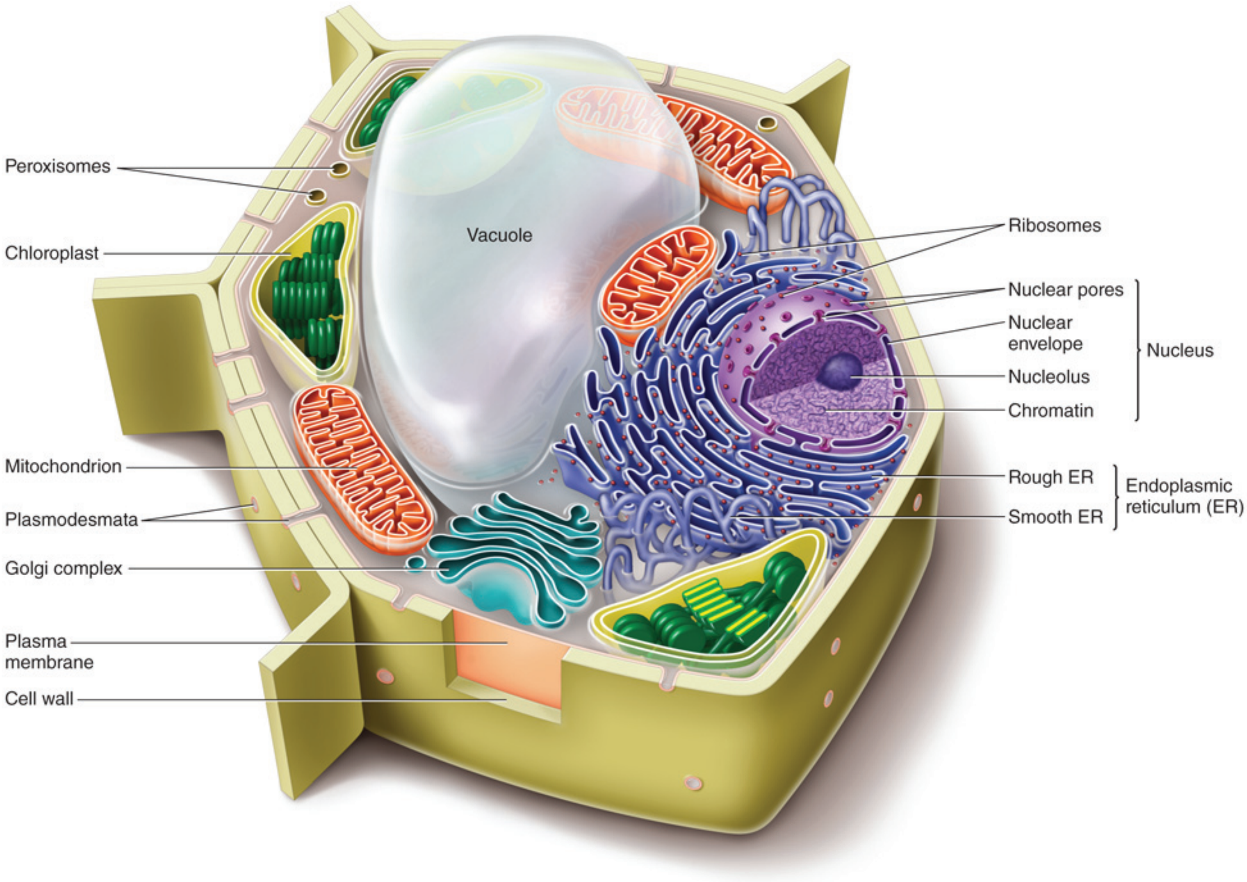
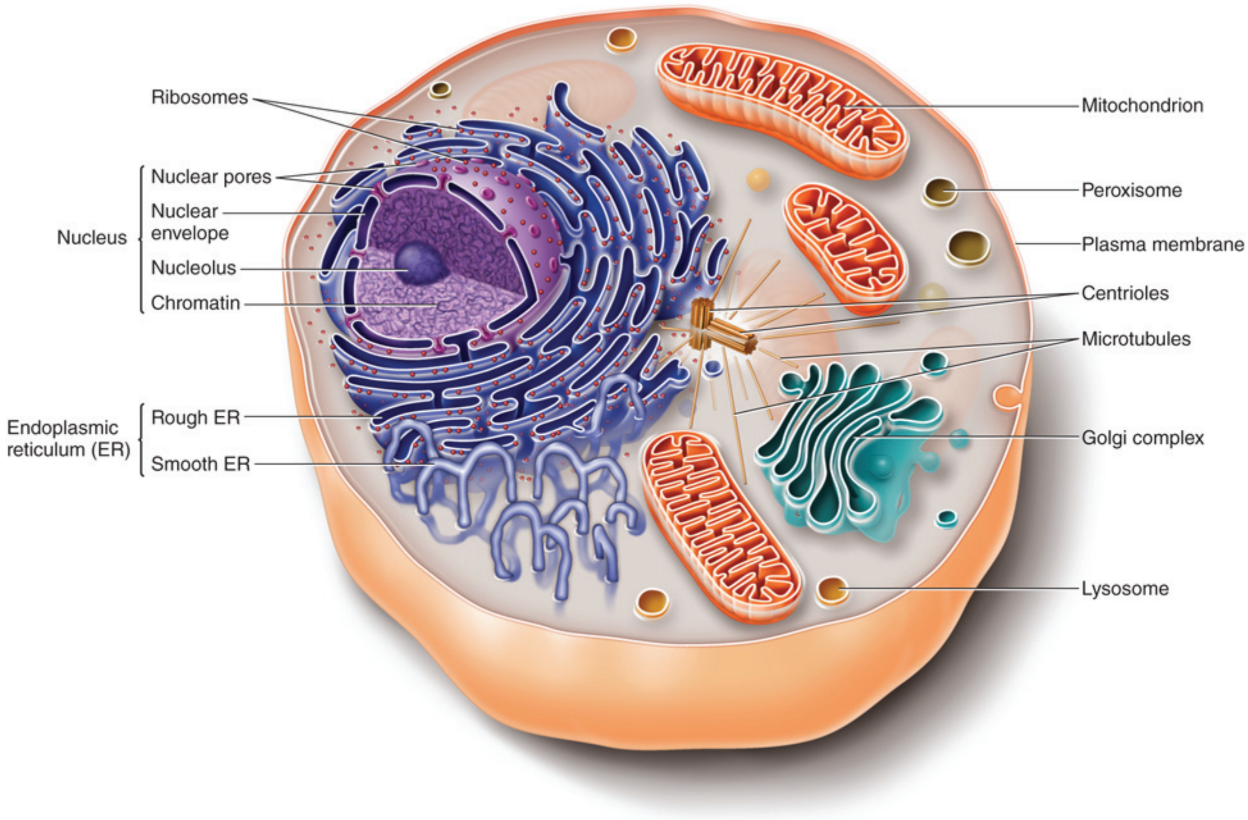


DRAGONFLY MEDIA GROUP

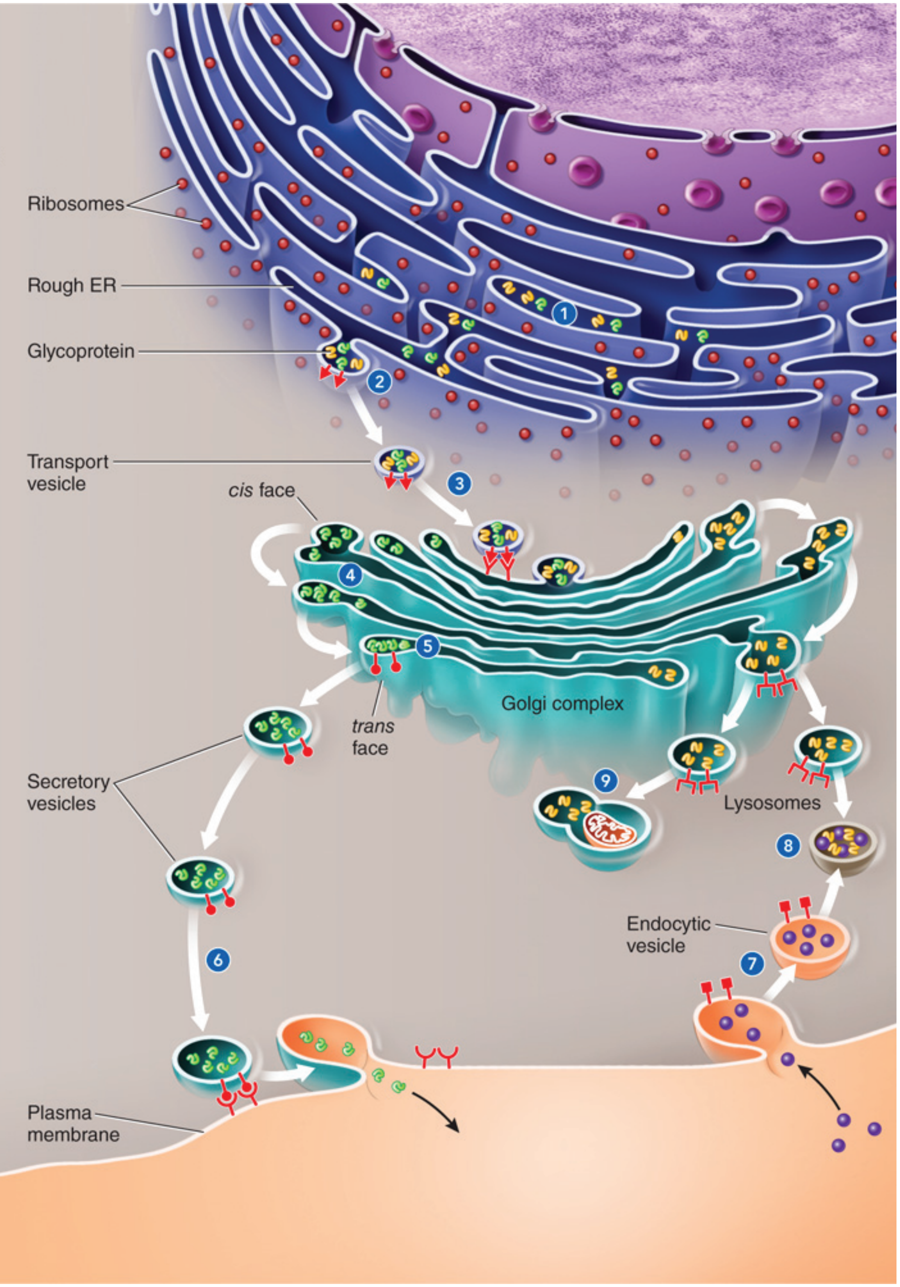


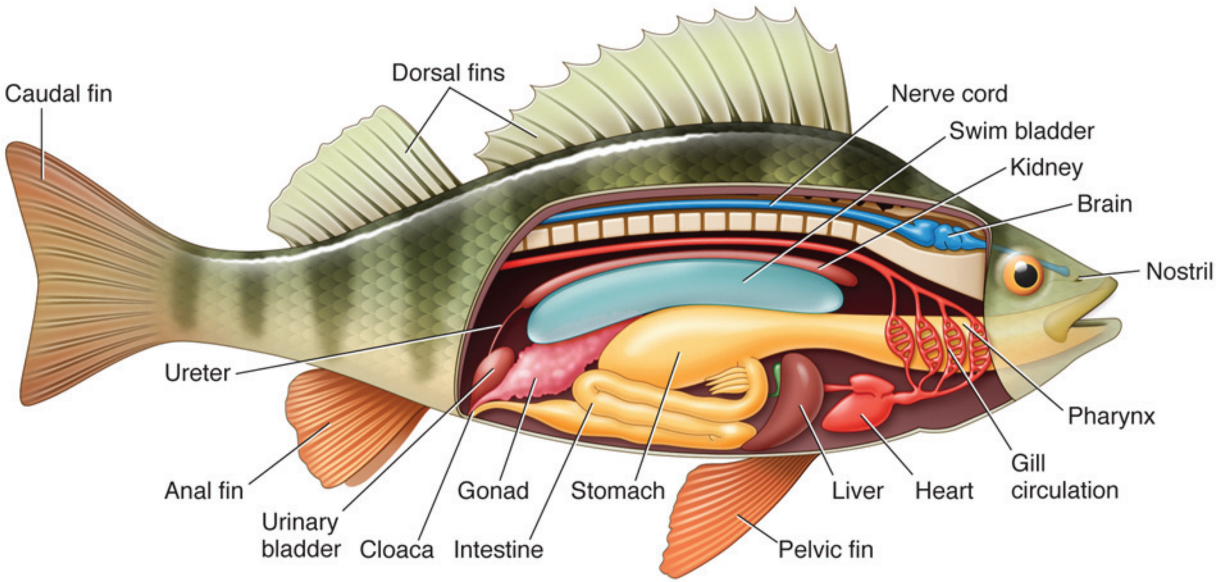
DRAGONFLY MEDIA GROUP

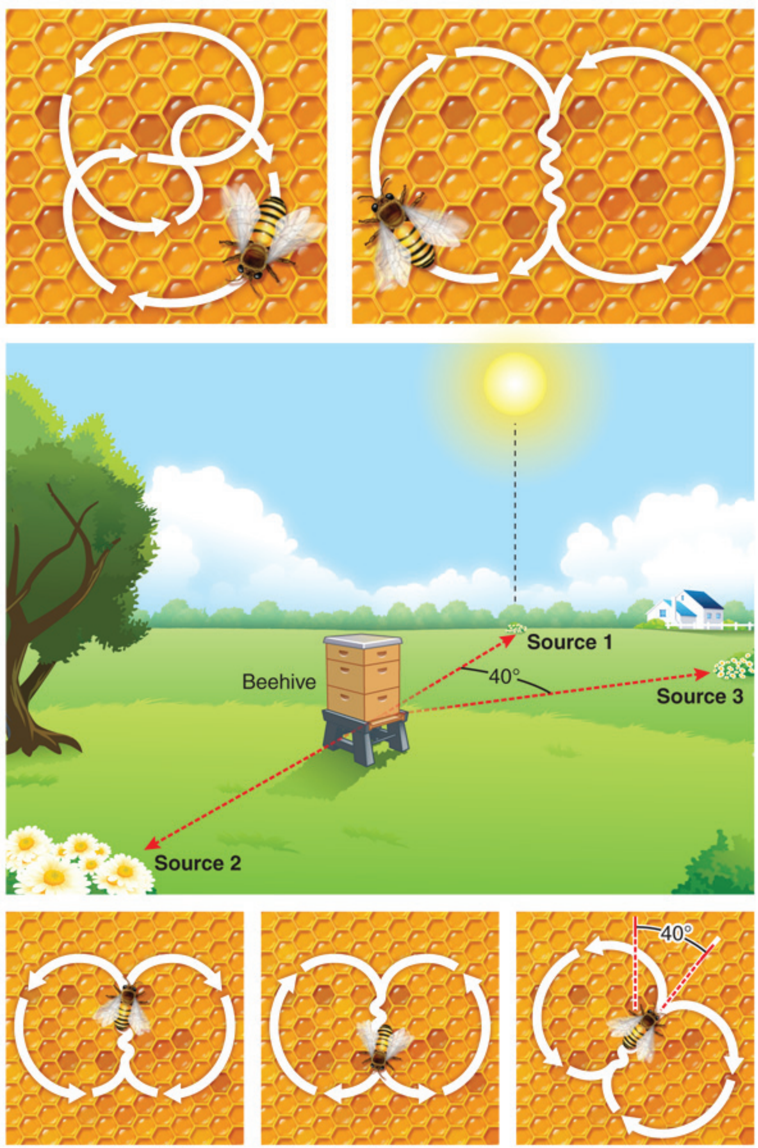

Peroxisomes
Chloroplast
Vacuole
Ribosomes
Nuclear pores
Nuclear envelope
Nucleolus
Chromatin
Nucleus
Mitochondrion
Plasmodesmata
Golgi complex
Rough ER
Smooth ER
Endoplasmic reticulum (ER)
Plasma membrane
Cell wall


Ribosomes
Nuclear pores
Nuclear envelope
Nucleus
Nucleolus
Chromatin
Endoplasmic reticulum (ER)
Rough ER
Smooth ER
Mitochondrion
Peroxisome
Plasma membrane
Centrioles
Microtubules
Golgi complex
Lysosome

1. Membrane-bound ribosomes insert proteins into the rough ER lumen.
2. Sugars are added in the ER lumen, forming glycoproteins.
3. Transport vesicles containing *cis* Golgi targeting signals on their surface dock with receptor molecules on the *cis* Golgi surface. Fusion of the vesicle with the Golgi membrane releases glycoproteins into a Golgi cisterna.
4. Glycoprotein sugars on proteins modified further in Golgi.
5. Glycoproteins are packaged on Golgi *trans* face into transport vesicles with targeting signals for the plasma membrane (secretory vesicles) or for lysosomes.
6. Secretory vesicles dock with targeting signals on the plasma membrane, triggering membrane fusion and release of contents from cell. Proteins and lipids from the secretory transport vesicle membrane become part of plasma membrane.
7. Endocytic vesicles containing lysosome targeting signals bud from plasma membrane.
8. Lysosomes released from *trans* Golgi fuse with endocytic vesicles.
9. Lysosomes released from *trans* Golgi may also fuse with vesicles containing damaged organelles, degrading and recycling contents.




Caudal fin
Dorsal fins
Nerve cord
Swim bladder
Kidney
Brain
Nostril
Ureter
Pharynx
Gill
circulation
Anal fin
Gonad
Stomach
Liver
Heart
Urinary
bladder
Cloaca
Intestine
Pelvic fin



Source 1: Located toward the sun

Source 2: Located opposite the sun

Source 3: Located 40 degrees to the right of the sun