

Life's Common Challenges

Nutritional Needs

The Need to Feed

- All life forms ("need to feed") they must acquire essential elements
- All organisms require nutrients...
 - ...take in, take apart and take up
- Nutrients must satisfy 3 needs
 - chemical energy
 - organic building blocks
 - essential elements

Chemical Energy

- The activities of cells, tissues, organs or even whole organisms depend on chemical energy
- This chemical energy is used to produce ATP ("cellular gasoline")
- **THE ULTIMATE SOURCE OF ENERGY USED BY CELLS TO PRODUCE ATP AND THE MECHANISM OF ATP PRODUCTION DOES VARY SOMEWHAT BETWEEN LIFE FORMS**

Carbon: Life's Building Blocks

- ❑ All cells require carbon and other atoms to build organic molecules that make up cells.
- ❑ Cells to large organisms use these raw materials to build, grow, repair and reproduce.
- ❑ **Once again, like energy, the source of these raw materials (mainly carbon) can and do vary from one life form to another.**

Essential Elements

- In addition to chemical energy and building blocks some organisms require essential elements from their environment...
- ...atoms / molecules that cells themselves can not synthesize
- ...they are needed to drive chemical reactions and complete the production of large organic molecules
- All living organisms require at least 17 essential elements. For all life together that number might be as high as 30. Some organisms require elements that others do not and how much each requires also varies.

Major Nutritional Modes

- ❑ **Phototrophs**: obtain energy from **light**
- ❑ **Chemotrophs**: obtain energy from **chemicals**
- ❑ **Autotrophs**: obtain carbon from **CO₂**
- ❑ **Heterotrophs**: obtain carbon from **organic sources**
- ❑ **COMBINING THE DIFFERENT SOURCES OF ENERGY AND CARBON RESULTS IN 4 MAJOR NUTRITIONAL MODES.**

Table 27.1 Major Nutritional Modes

Mode of Nutrition	Energy Source	Carbon Source	Types of Organisms
Autotroph			
Photoautotroph	Light	CO ₂	Photosynthetic prokaryotes (for example, cyanobacteria); plants; certain protists (for example, algae)
Chemoautotroph	Inorganic chemicals	CO ₂	Certain prokaryotes (for example, <i>Sulfolobus</i>)
Heterotroph			
Photoheterotroph	Light	Organic compounds	Certain prokaryotes (for example, <i>Rhodobacter</i> , <i>Chloroflexus</i>)
Chemoheterotroph	Organic compounds	Organic compounds	Many prokaryotes (for example, <i>Clostridium</i>) and protists; fungi; animals; some plants

Animals

Nutritional Requirements

Diverse Diets

- All animals eat other organisms...dead or alive
- Animals must eat for both energy and building blocks
- **HERBIVORES- EAT PLANTS OR ALGAE**
- **CARNIVORES- EAT OTHER ANIMALS**
- **OMNIVORES- EAT EITHER PLANTS, ALGAE AND/OR ANIMALS**
- Most animals are opportunistic feeders, eating foods outside their standard diet when usual foods are unavailable

Nutritional Needs

- ❑ Animals must acquire nutrients for both **energy** and **building blocks**
- ❑ Animals must consume sugars, fats and proteins
- ❑ These macromolecules provide the energy for cellular respiration and provide the raw materials for biosynthesis
- ❑ In addition animals require certain specific **essential elements** usually needed in much smaller amounts

Essential Nutrients

- Animals require 4 classes of essential nutrients
 - **ESSENTIAL AMINO ACIDS**
 - **ESSENTIAL FATTY ACIDS**
 - **VITAMINS**
 - **MINERALS**
- 



Essential Amino Acids

- ❑ *Animals require 20 amino acids to make proteins*
 - ❑ Most animals can make 12 of the 20 amino acids
 - ❑ *However the remaining 8 "essential amino acids" can only be obtained through diet*
 - ❑ Some animal proteins are called "complete proteins" because they have all 20 amino acids
 - ❑ for example meat, eggs and cheese
- ❑ vegetarians can get all 20 amino acids by eating a varied diet of plant proteins

Essential amino acids for adults

Methionine

Valine

Threonine

Phenylalanine

Leucine

Isoleucine

Tryptophan

Lysine

**Beans
and other
legumes**



**Corn (maize)
and other grains**

Essential Fatty Acids

- ❑ *Animals can make most, but not all fatty acids*
- ❑ for example omega-3's and omega-6 fatty acids
- ❑ found in canola oil, fish, walnut, pumpkin seeds, sunflower seeds, shellfish, leafy veggies



Vitamins

- **Organic molecules** with diverse functions usually needed in small amounts
- important for many metabolic processes, including cellular respiration

Table 41.1 Vitamin Requirements of Humans

Vitamin	Major Dietary Sources	Major Functions in the Body	Symptoms of Deficiency or Extreme Excess
Fat-Soluble Vitamins			
Vitamin A (retinol)	Provitamin A (beta-carotene) in deep green and orange vegetables and fruits; retinal in dairy products	Component of visual pigments; maintenance of epithelial tissues; antioxidant; helps prevent damage to cell membranes	Blindness and increased death rate Headache, irritability, vomiting, hair loss, blurred vision, liver and bone damage
Vitamin D	Dairy products, egg yolk; also made in human skin in presence of sunlight	Aids in absorption and use of calcium and phosphorus; promotes bone growth	Rickets (bone deformities) in children, bone softening in adults Brain, cardiovascular, and kidney damage
Vitamin E (tocopherol)	Vegetable oils, nuts, seeds	Antioxidant; helps prevent damage to cell membranes	Degeneration of the nervous system
Vitamin K (phylloquinone)	Green vegetables, tea; also made by colon bacteria	Important in blood clotting	Defective blood clotting Liver damage and anemia

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Table 41.1 Vitamin Requirements of Humans

Vitamin	Major Dietary Sources	Major Functions in the Body	Symptoms of Deficiency or Extreme Excess
Water-Soluble Vitamins			
Vitamin B ₁ (thiamine)	Pork, legumes, peanuts, whole grains	Coenzyme used in removing CO ₂ from organic compounds	Beriberi (nerve disorders, emaciation, anemia)
Vitamin B ₂ (riboflavin)	Dairy products, meats, enriched grains, vegetables	Component of coenzymes FAD and FMN	Skin lesions such as cracks at corners of mouth
Niacin (B ₃)	Nuts, meats, grains	Component of coenzymes NAD ⁺ and NADP ⁺	Skin and gastrointestinal lesions, nervous disorders Liver damage
Vitamin B ₆ (pyridoxine)	Meats, vegetables, whole grains	Coenzyme used in amino acid metabolism	Irritability, convulsions, muscular twitching, anemia Unstable gait, numb feet, poor coordination
Pantothenic acid (B ₅)	Most foods: meats, dairy products, whole grains, etc.	Component of coenzyme A	Fatigue, numbness, tingling of hands and feet
Folic acid (folacin) (B ₉)	Green vegetables, oranges, nuts, legumes, whole grains	Coenzyme in nucleic acid and amino acid metabolism	Anemia, birth defects May mask deficiency of vitamin B₁₂
Vitamin B ₁₂	Meats, eggs, dairy products	Coenzyme in nucleic acid metabolism; maturation of red blood cells	Anemia, nervous system disorders
Biotin	Legumes, other vegetables, meats	Coenzyme in synthesis of fat, glycogen, and amino acids	Scaly skin inflammation, neuromuscular disorders
Vitamin C (ascorbic acid)	Fruits and vegetables, especially citrus fruits, broccoli, cabbage, tomatoes, green peppers	Used in collagen synthesis (such as for bone, cartilage, gums); antioxidant; aids in detoxification; improves iron absorption	Scurvy (degeneration of skin, teeth, blood vessels), weakness, delayed wound healing, impaired immunity Gastrointestinal upset

Minerals

- ❑ *Inorganic molecules* with diverse functions usually needed in small amounts
- ❑ important for many metabolic processes, including enzymes, nerve impulses, building bone



Table 41.2 Mineral Requirements of Humans

Mineral	Major Dietary Sources	Major Functions in the Body	Symptoms of Deficiency*	
Greater than 200 mg per day required	Calcium (Ca)	Dairy products, dark green vegetables, legumes	Bone and tooth formation, blood clotting, nerve and muscle function	Retarded growth, possibly loss of bone mass
	Phosphorus (P)	Dairy products, meats, grains	Bone and tooth formation, acid-base balance, nucleotide synthesis	Weakness, loss of minerals from bone, calcium loss
	Sulfur (S)	Proteins from many sources	Component of certain amino acids	Symptoms of protein deficiency
	Potassium (K)	Meats, dairy products, many fruits and vegetables, grains	Acid-base balance, water balance, nerve function	Muscular weakness, paralysis, nausea, heart failure
	Chlorine (Cl)	Table salt	Acid-base balance, formation of gastric juice, nerve function, osmotic balance	Muscle cramps, reduced appetite
	Sodium (Na)	Table salt	Acid-base balance, water balance, nerve function	Muscle cramps, reduced appetite
	Magnesium (Mg)	Whole grains, green leafy vegetables	Cofactor; ATP bioenergetics	Nervous system disturbances
Iron (Fe)	Meats, eggs, legumes, whole grains, green leafy vegetables	Component of hemoglobin and of electron carriers in energy metabolism; enzyme cofactor	Iron-deficiency anemia, weakness, impaired immunity	

*All of these minerals are also harmful when consumed in excess.

Table 41.2 Mineral Requirements of Humans

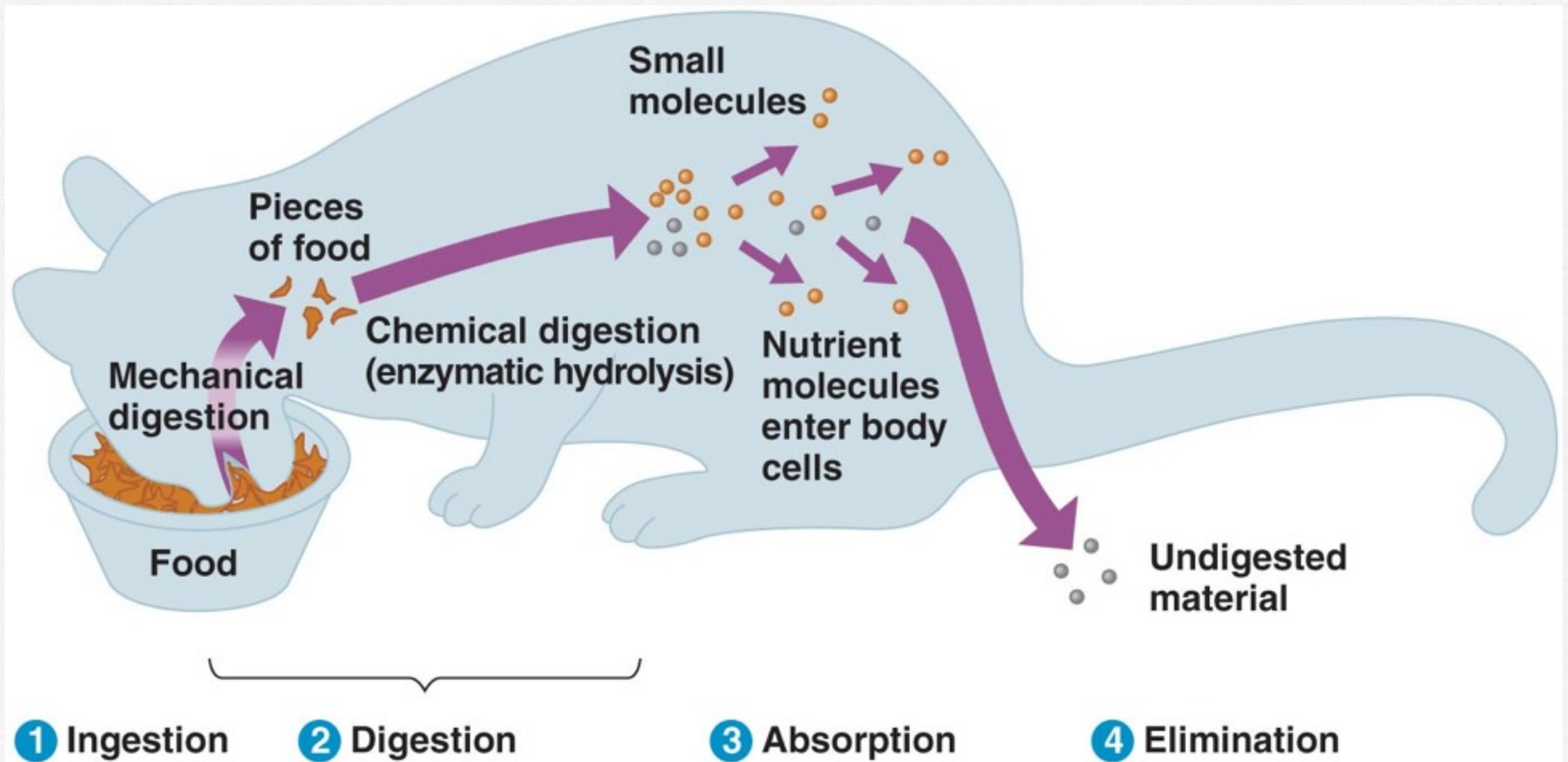
Mineral	Major Dietary Sources	Major Functions in the Body	Symptoms of Deficiency*
Fluorine (F)	Drinking water, tea, seafood	Maintenance of tooth (and probably bone) structure	Higher frequency of tooth decay
Zinc (Zn)	Meats, seafood, grains	Component of certain digestive enzymes and other proteins	Growth failure, skin abnormalities, reproductive failure, impaired immunity
Copper (Cu)	Seafood, nuts, legumes, organ meats	Enzyme cofactor in iron metabolism, melanin synthesis, electron transport	Anemia, cardiovascular abnormalities
Manganese (Mn)	Nuts, grains, vegetables, fruits, tea	Enzyme cofactor	Abnormal bone and cartilage
Iodine (I)	Seafood, dairy products, iodized salt	Component of thyroid hormones	Goiter (enlarged thyroid)
Cobalt (Co)	Meats and dairy products	Component of vitamin B ₁₂	None, except as B ₁₂ deficiency
Selenium (Se)	Seafood, meats, whole grains	Enzyme cofactor; antioxidant functioning in close association with vitamin E	Muscle pain, possibly heart muscle deterioration
Chromium (Cr)	Brewer's yeast, liver, seafood, meats, some vegetables	Involved in glucose and energy metabolism	Impaired glucose metabolism
Molybdenum (Mo)	Legumes, grains, some vegetables	Enzyme cofactor	Disorder in excretion of nitrogen-containing compounds

*All of these minerals are also harmful when consumed in excess.

Animals

Nutritional Processing

4 Stages of Food Processing



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Ingestion

- ❑ **INGESTION-** the act of feeding or or eating
- ❑ variation in food = variation in feeding mechanisms
- ❑ see slides that follow



Suspension & Filter Feeders

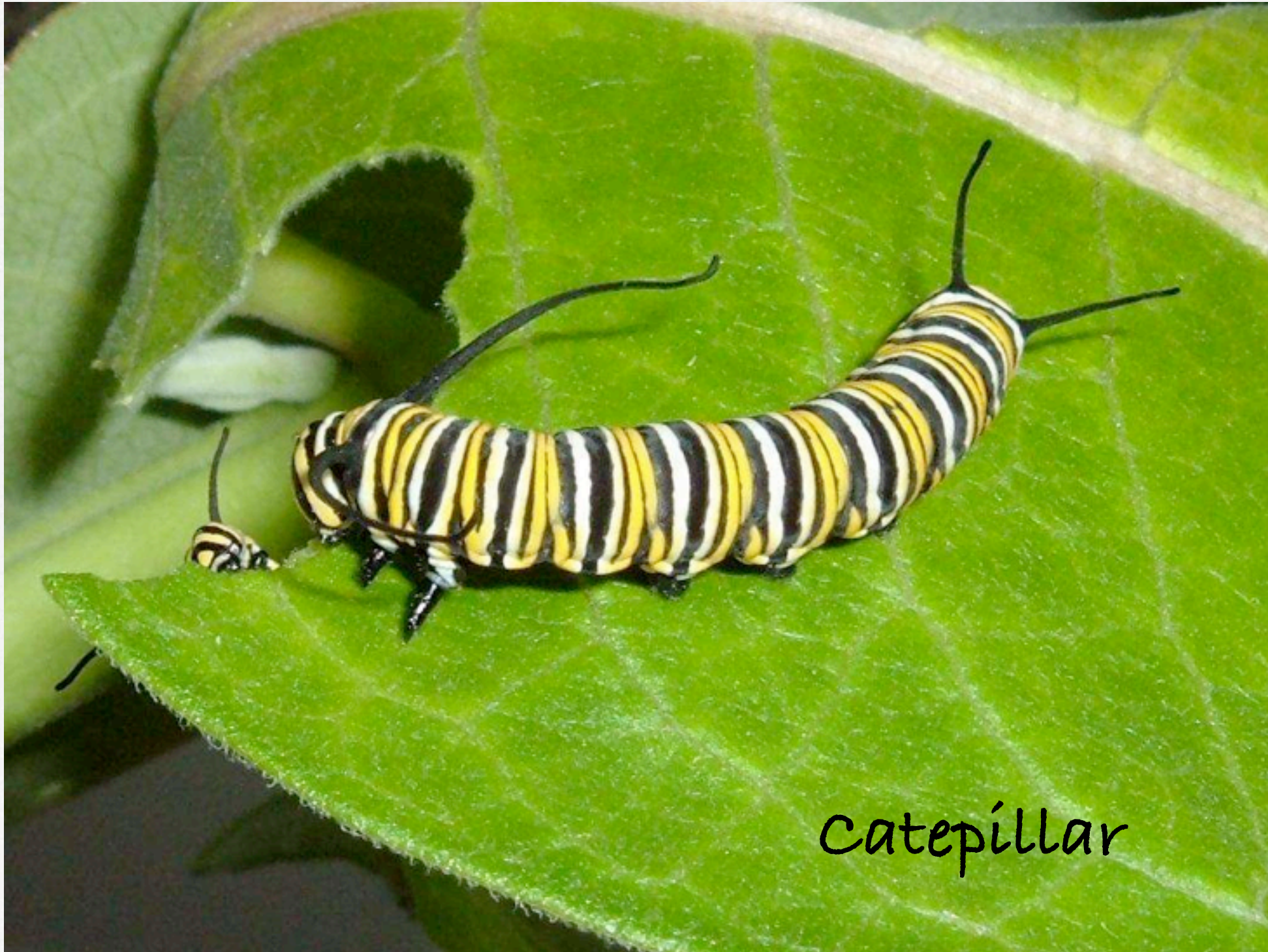
eat small
food
particles
suspended
in water



Basking Shark

Substrate Feeders

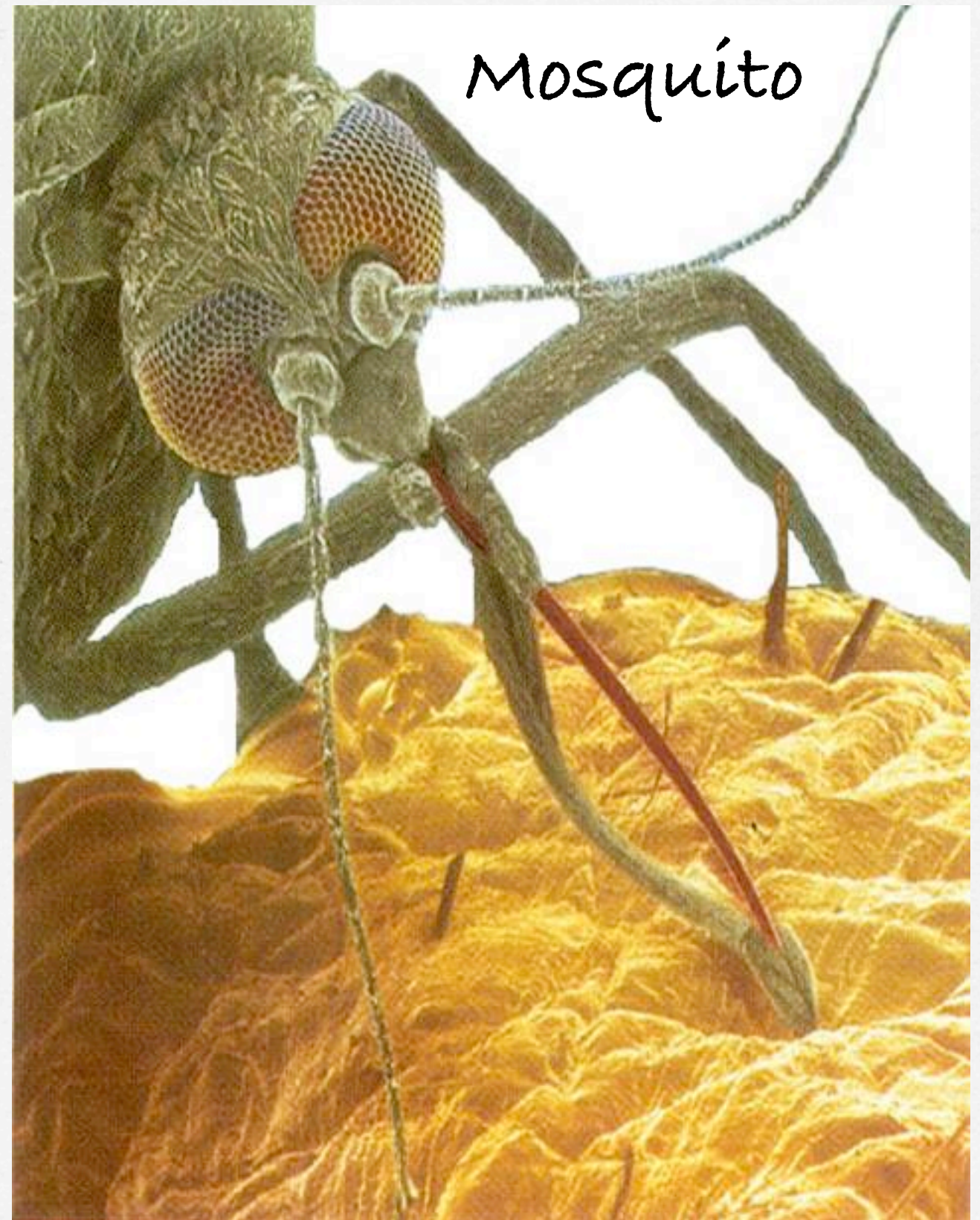
live in or on
their food
source



Catepillar

Fluid Feeders

suck nutrient rich fluid from a living host



Bulk Feeders eat relatively large pieces of food



Rock Python

Digestion

- ❑ **DIGESTION**- breaking food into particles small enough to be absorbed into cells (increases SA:V)
- ❑ **MECHANICAL DIGESTION**-physical breakdown of food, into smaller pieces...increasing surface area
- ❑ **CHEMICAL DIGESTION**-breakdown of molecules into their subunits
 - ❑ this allows passage across membranes
 - ❑ and each organism needs to build its own specific molecules

Absorption

- ❑ **ABSORPTION-** the act of taking up small molecules such as simple sugars and amino acids

Elimination

- ❑ **ELIMINATION-** the act of passing undigested material out of the digestive system

Digestive Compartments

How are animals able to digest molecules that they themselves are made of?

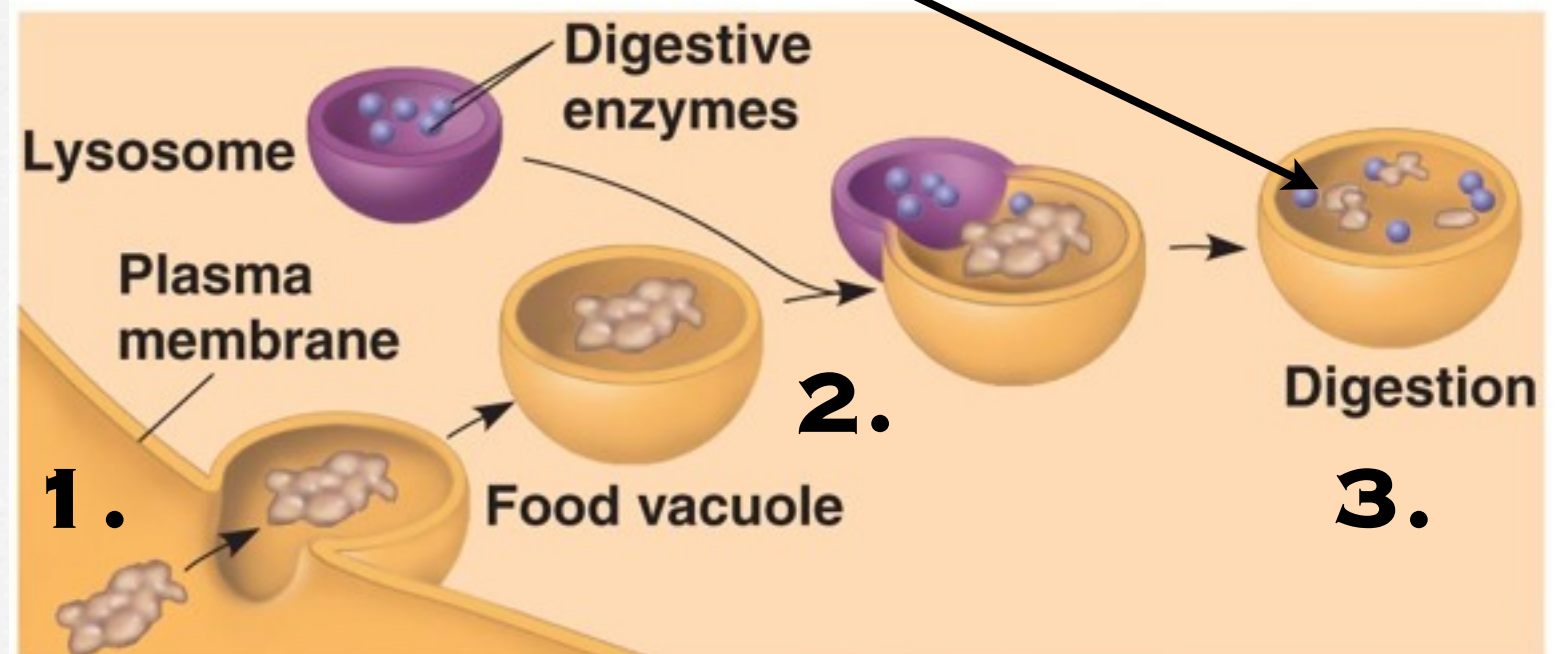
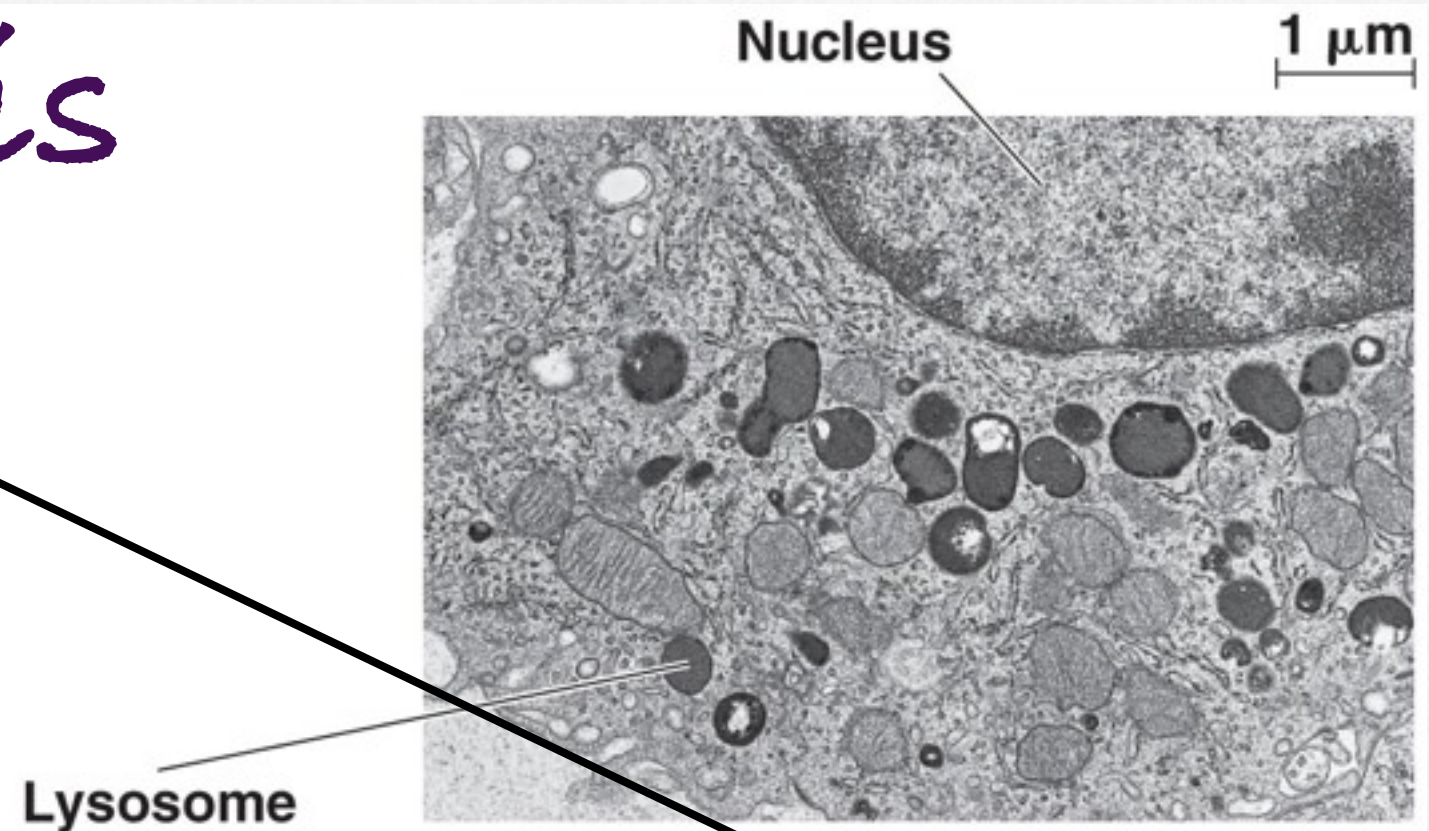
- The evolutionary adaptation found across a wide range of organisms is the processing of food within specialized compartments.
- These compartments can be intracellular (vacuoles) or extracellular (digestive organs)

Intracellular Compartments

- ❑ **FOOD VACUOLES** - cellular organelles in which enzymes break down food (simplest digestive compartments).
- ❑ Cell engulfs food by **PHAGOCYTOSIS**
- ❑ Food vacuole fuses with **LYSOSOME** (digestive sac)
- ❑ Digestion occurs safely inside compartment
- ❑ Few animals digest food exclusively this way, the sponge however is one organism that does.

Phagocytosis

Now nutrients for cell



(a) Phagocytosis

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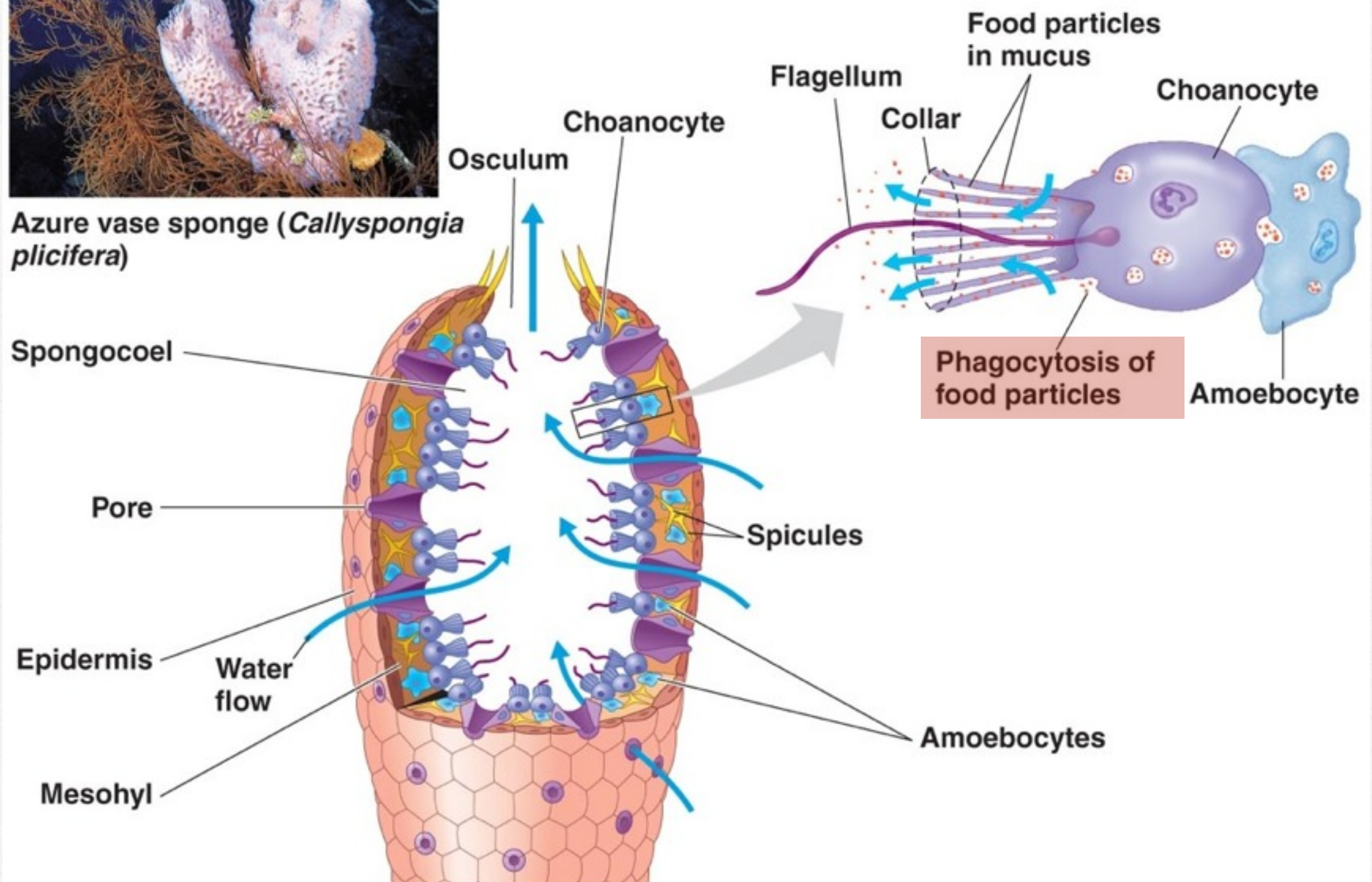
Mead's Microbe Movies

"Amoebic Endocytosis"

©2001 JS MEAD



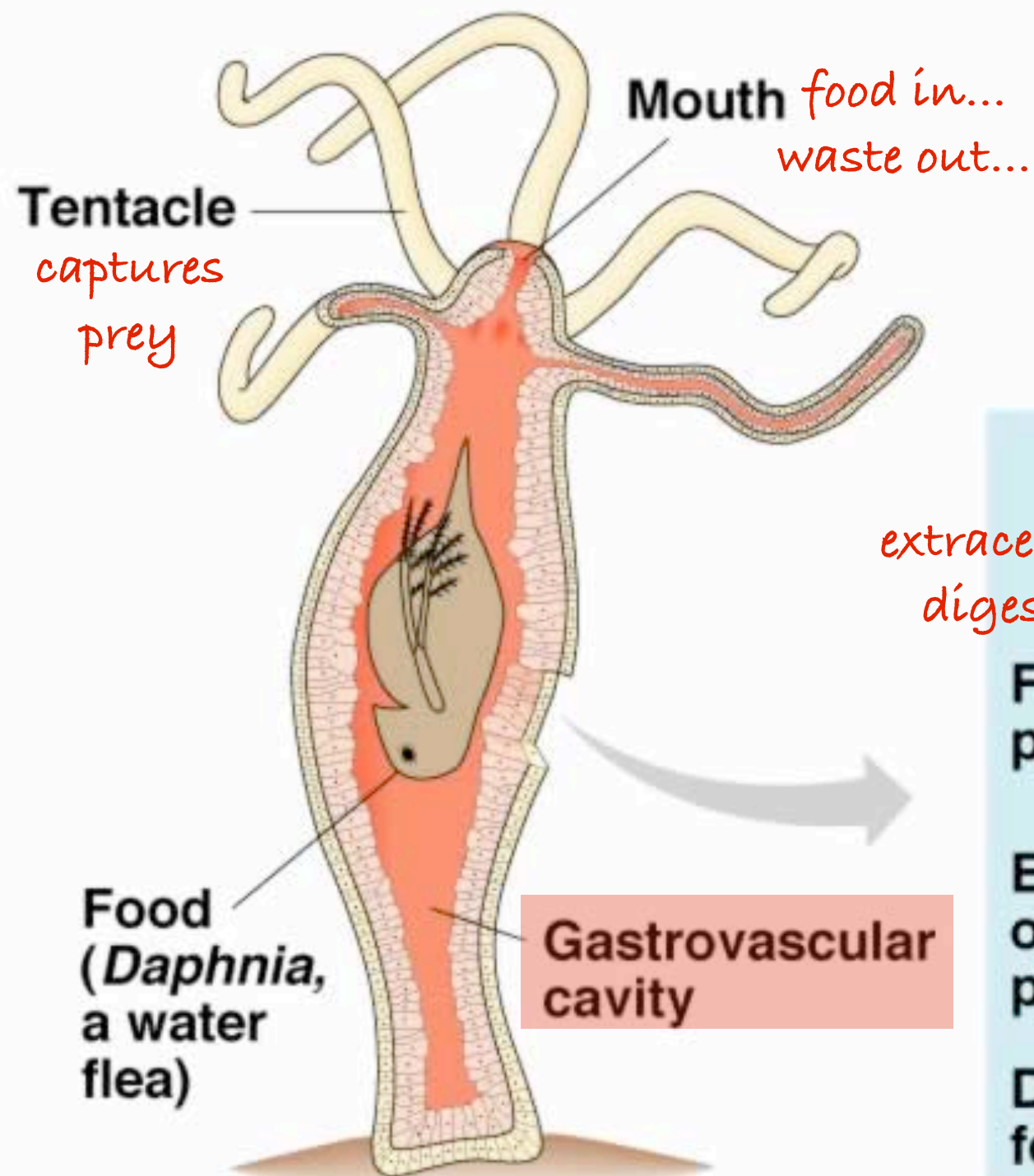
Azure vase sponge (*Callyspongia plicifera*)



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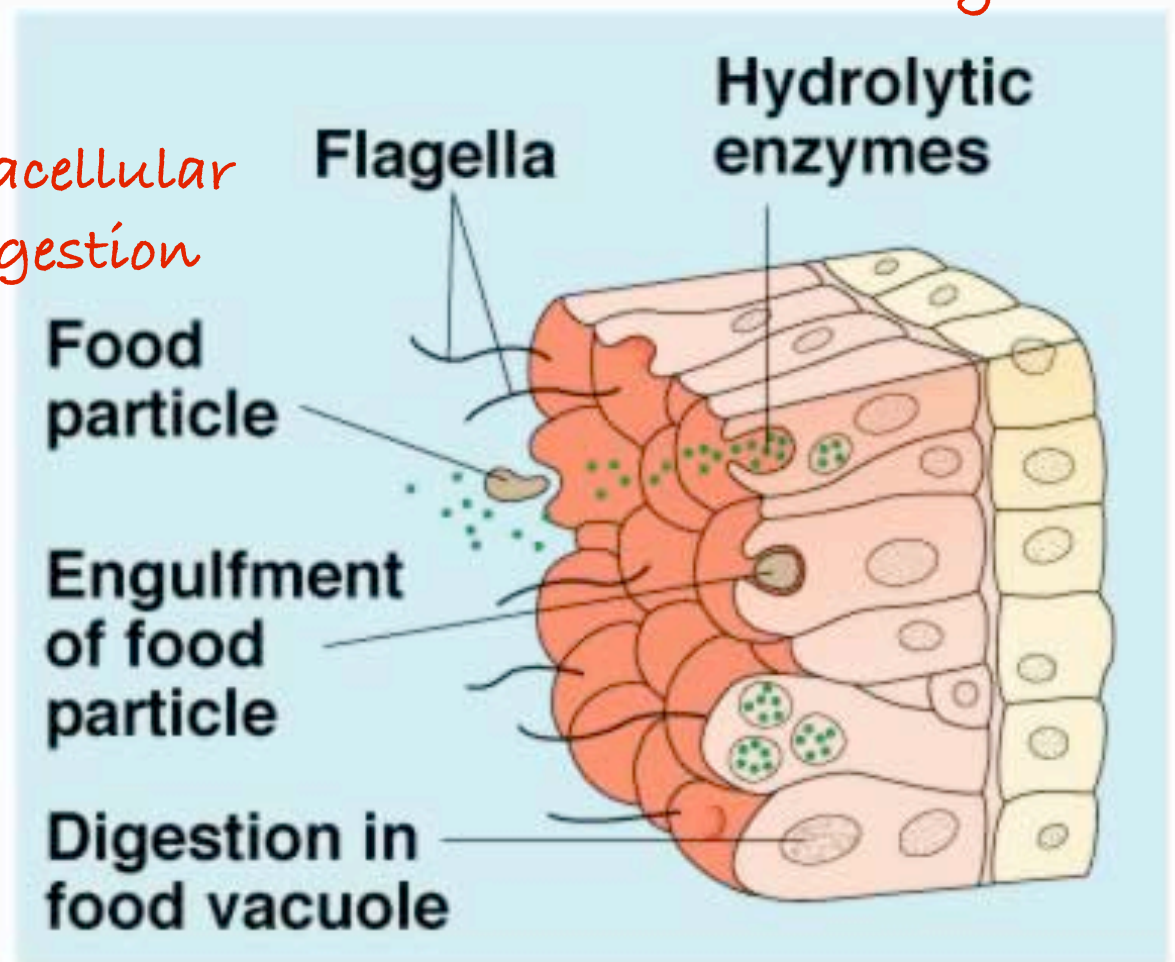
Extracellular Compartments

- Most animal species, molecular breakdown occurs by extracellular digestion, in compartments that continuous with outside of the animal's body.
- Some animals with simple body plans have digestive compartments with a single opening
 - ex. Hydra
- Most animals have a digestive tube extending between two openings: mouth and anus.
 - This tube is called **ALIMENTARY CANAL**

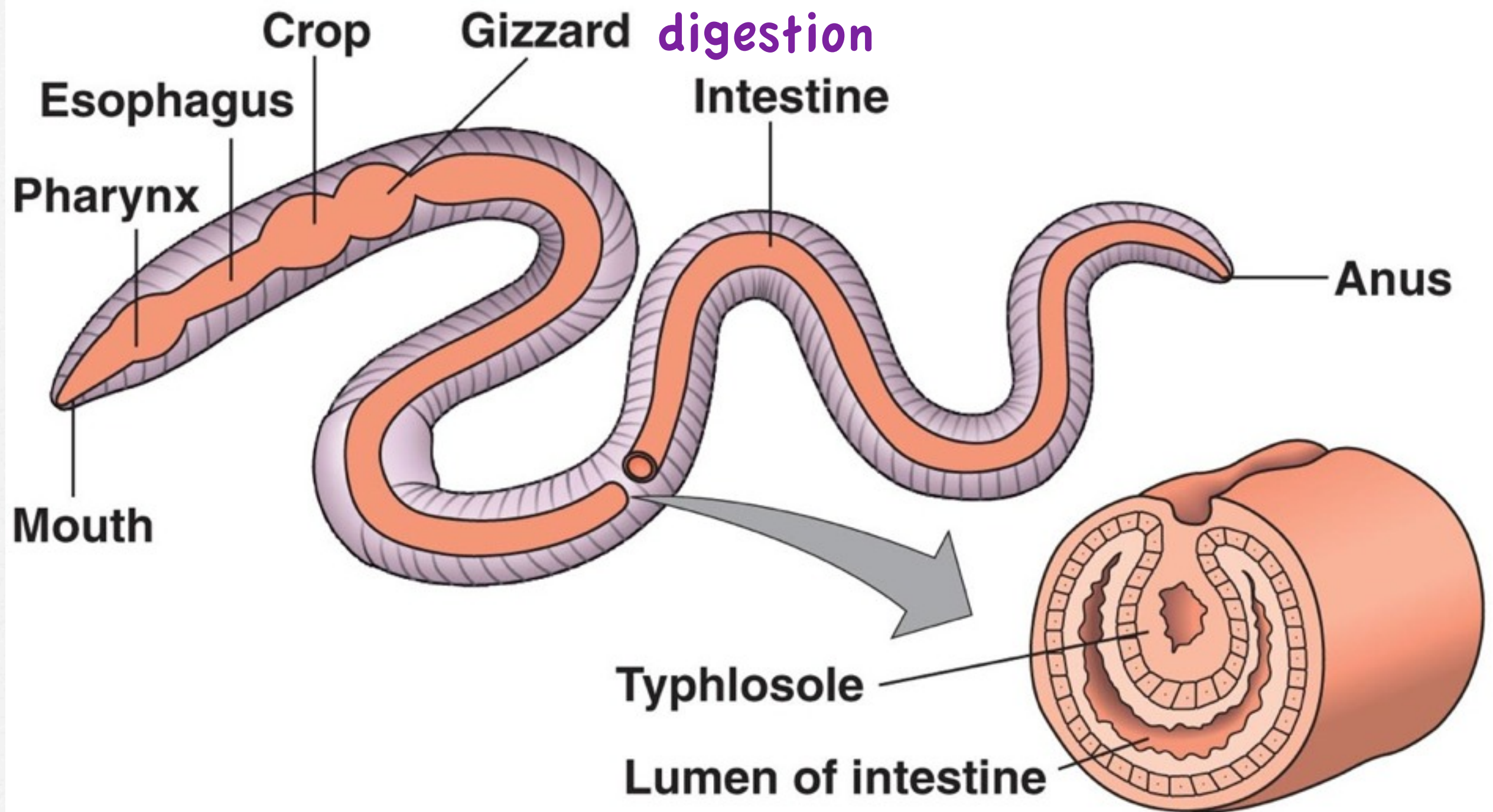


extracellular digestion

secretes enzymes

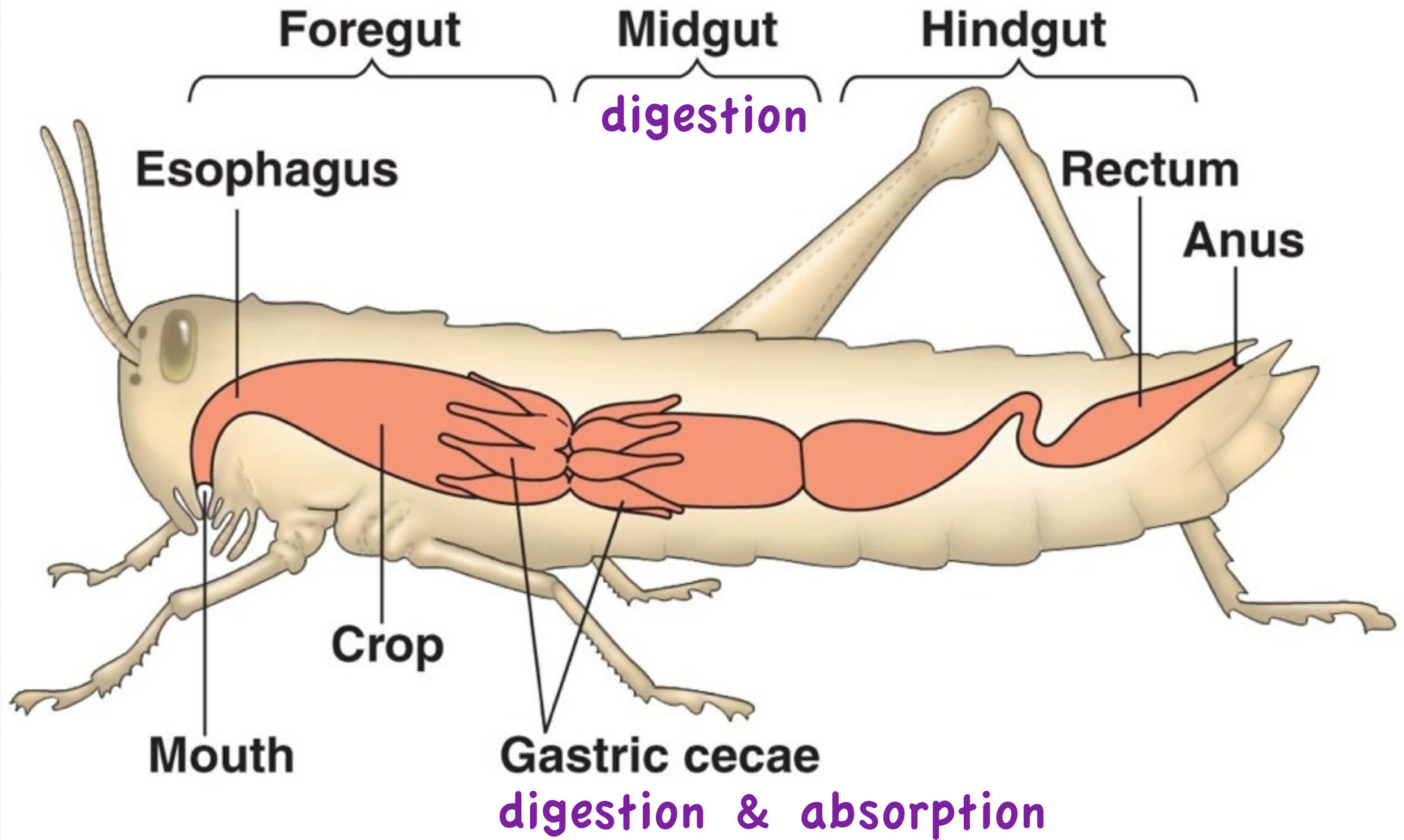


intracellular digestion



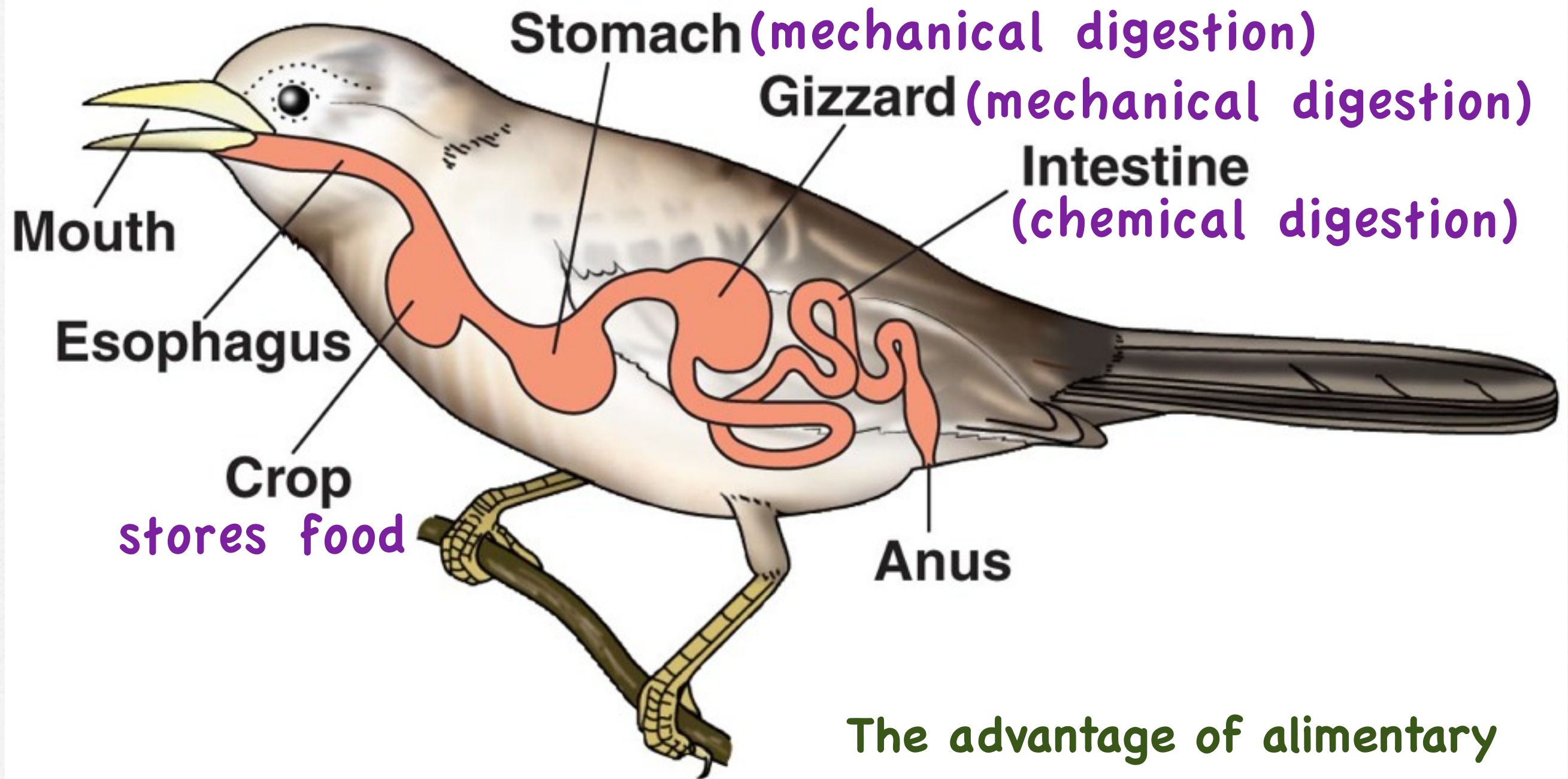
(a) Earthworm

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(b) Grasshopper

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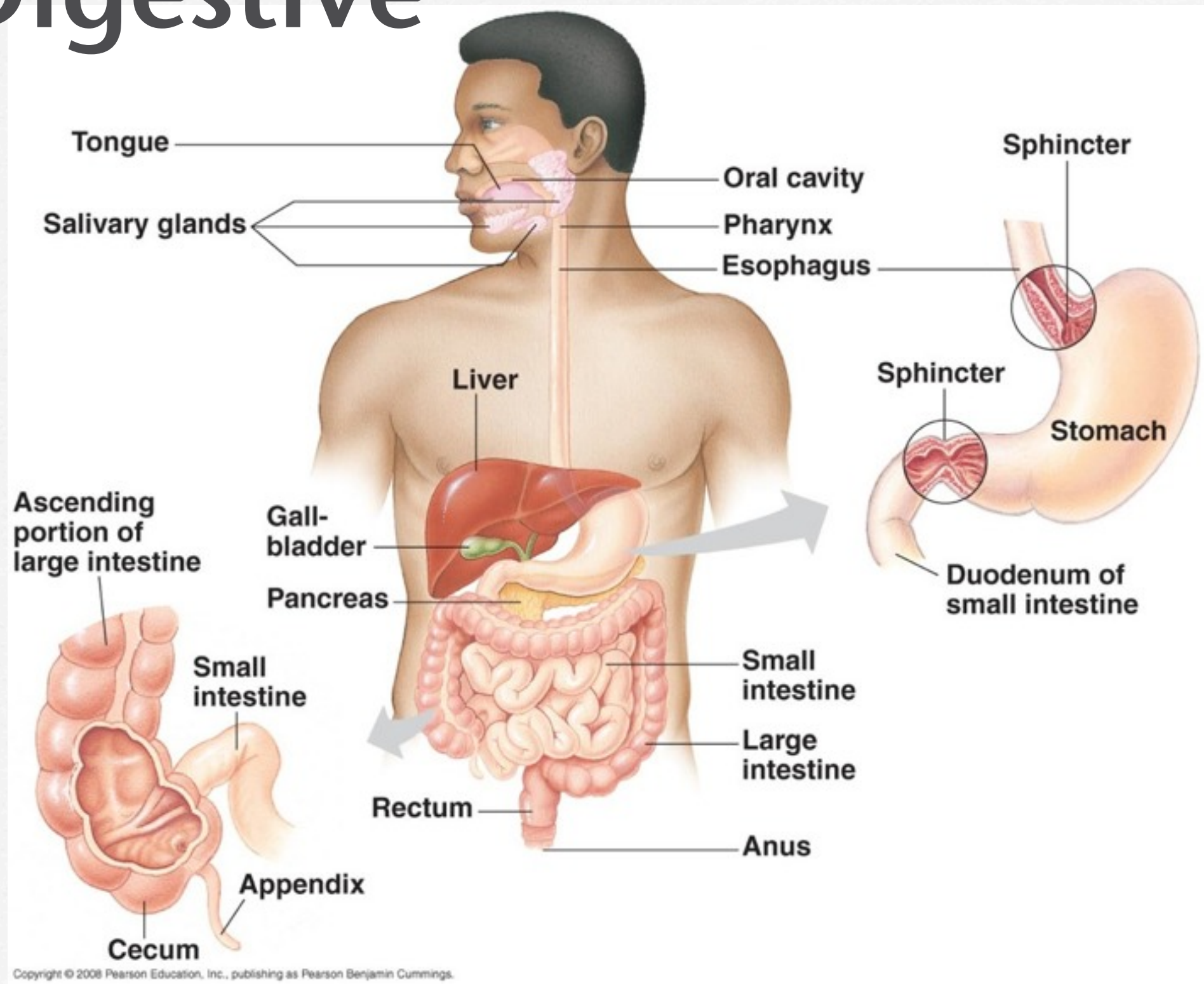


(c) Bird

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The advantage of alimentary canals is specialization and food can be digested while an earlier meal is being absorbed

Human Digestive System

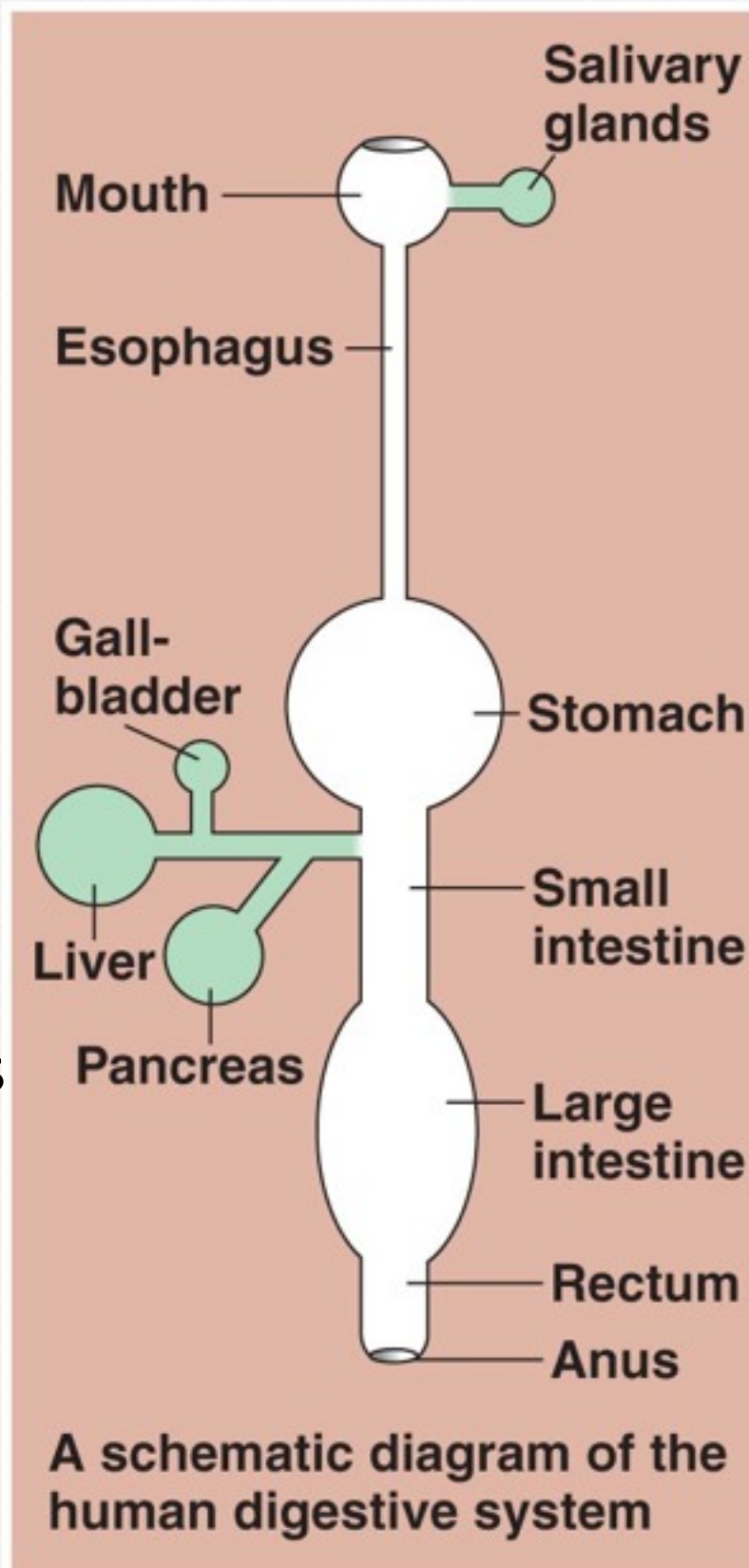


mechanical digestion

stores bile

makes bile
detoxifies

digestive enzymes



starts chemical
digestion

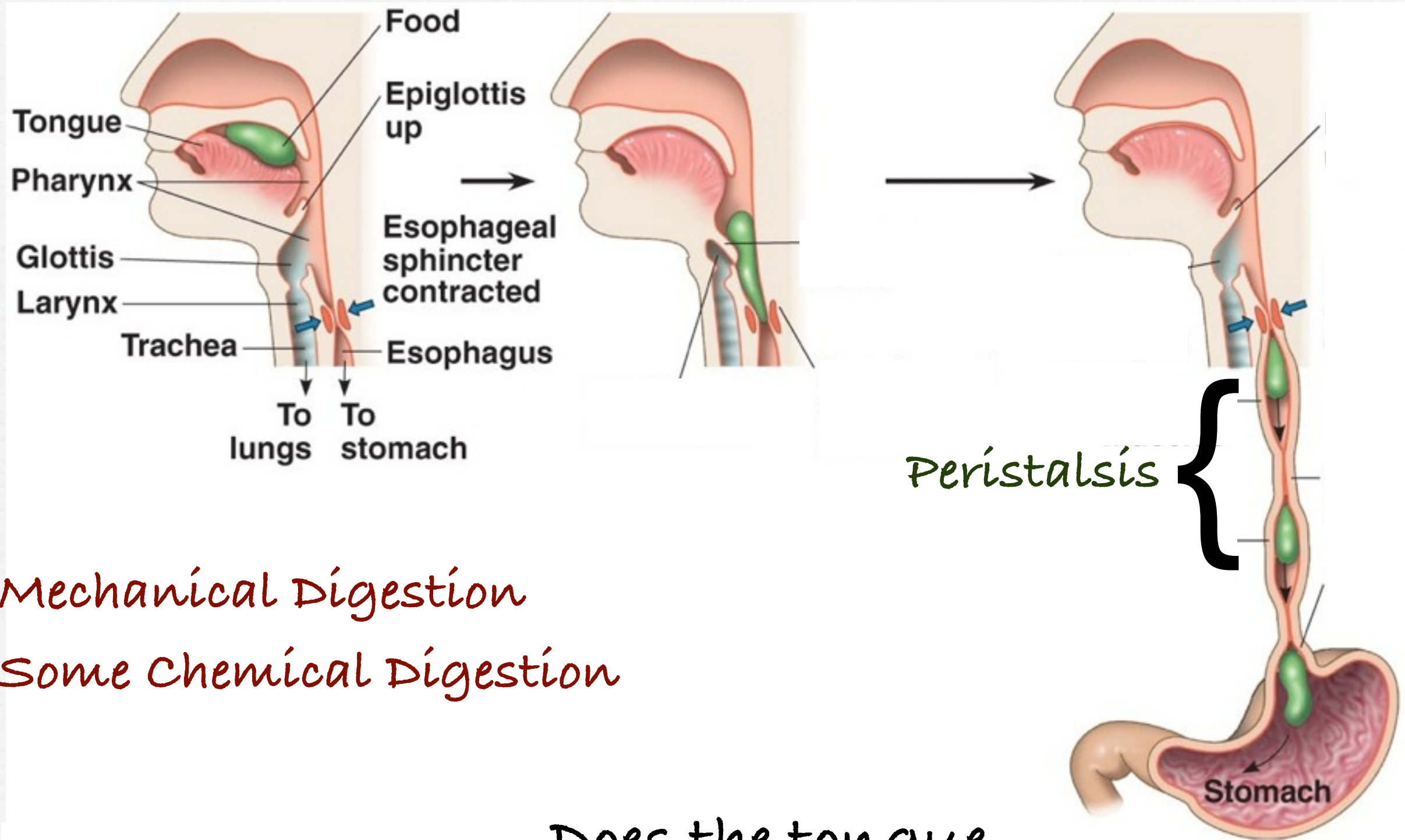
food storage
mechanical digestion

chemical digestion
absorption

absorption

waste storage

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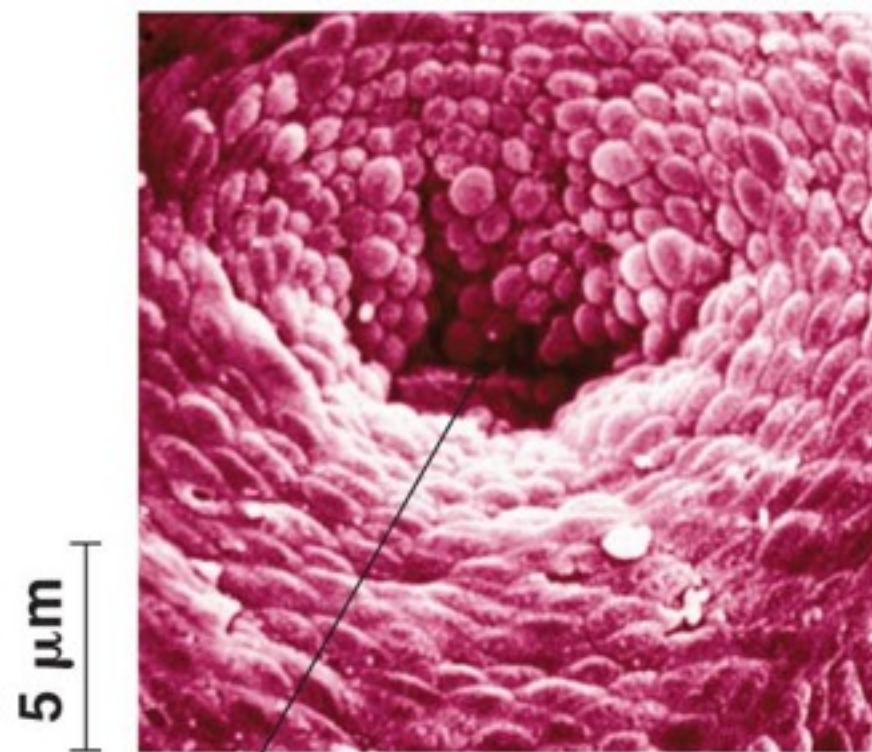
Mechanical Digestion
Some Chemical Digestion

Does the tongue
have any function?

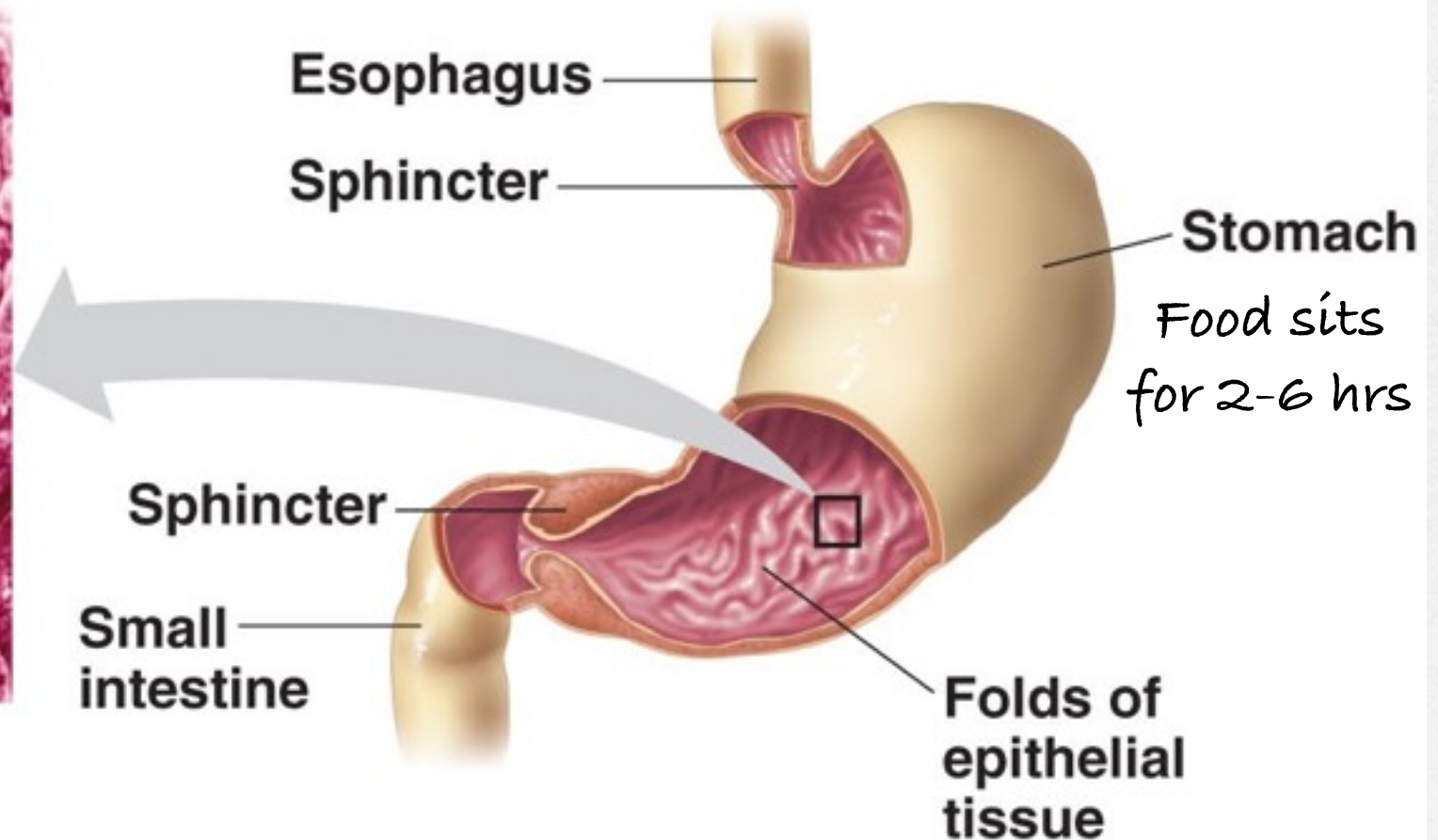
Mainly Storage

Chemical Digestion

Some Mechanical Digestion



Interior surface
of stomach

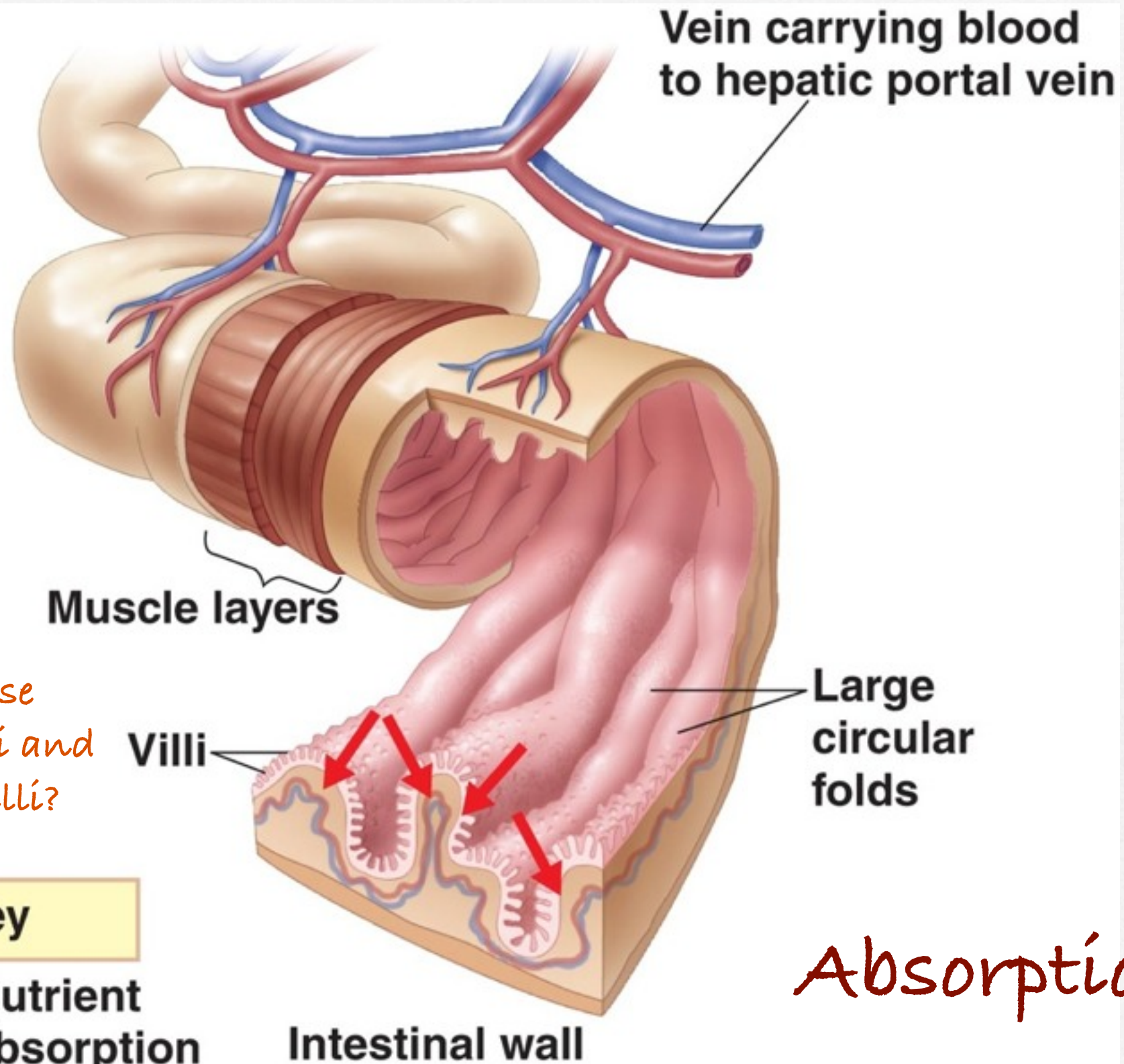


very acidic...why?

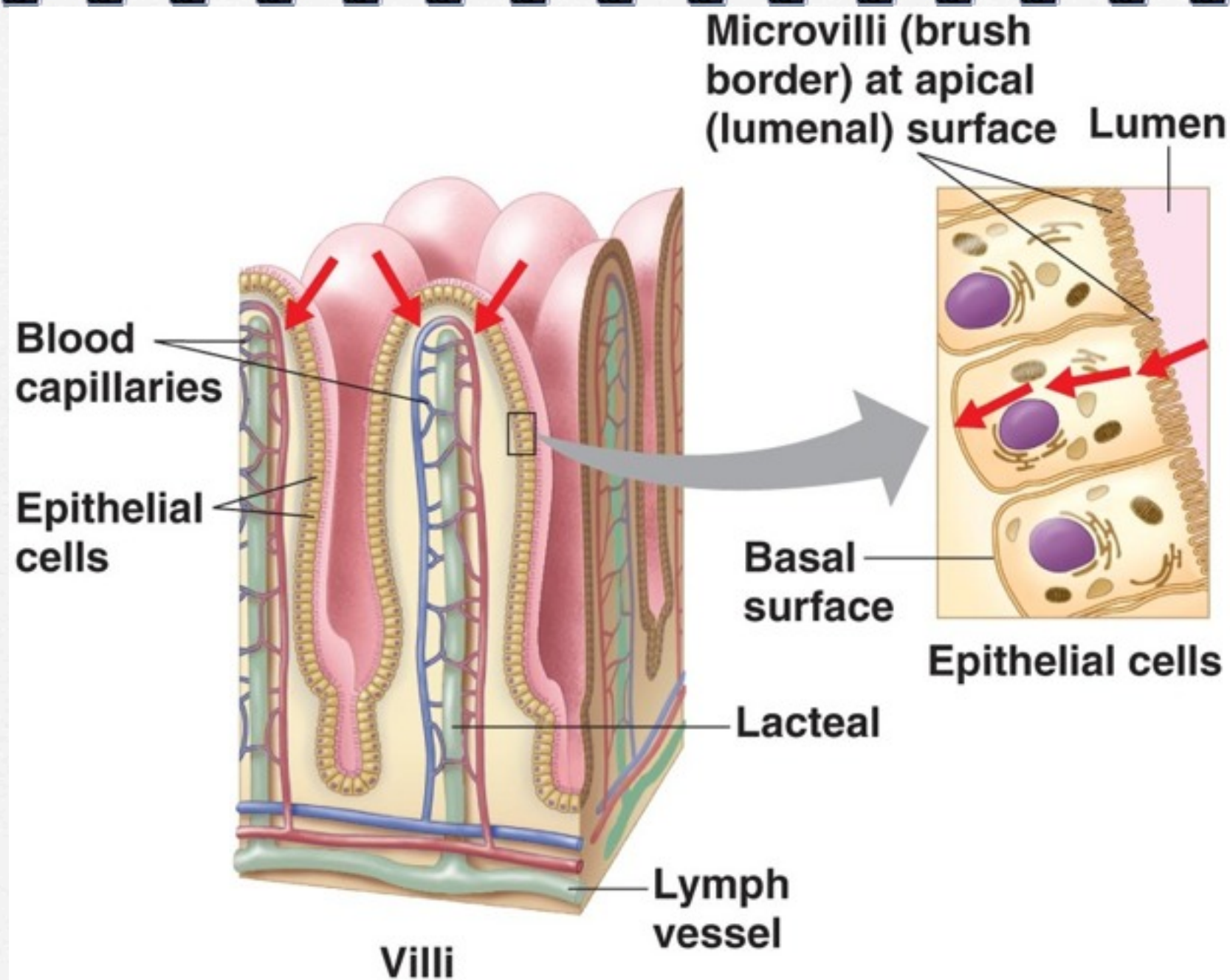
Chemical Digestion

over 20 feet long

What is the purpose behind the folds, villi and the unseen microvilli?

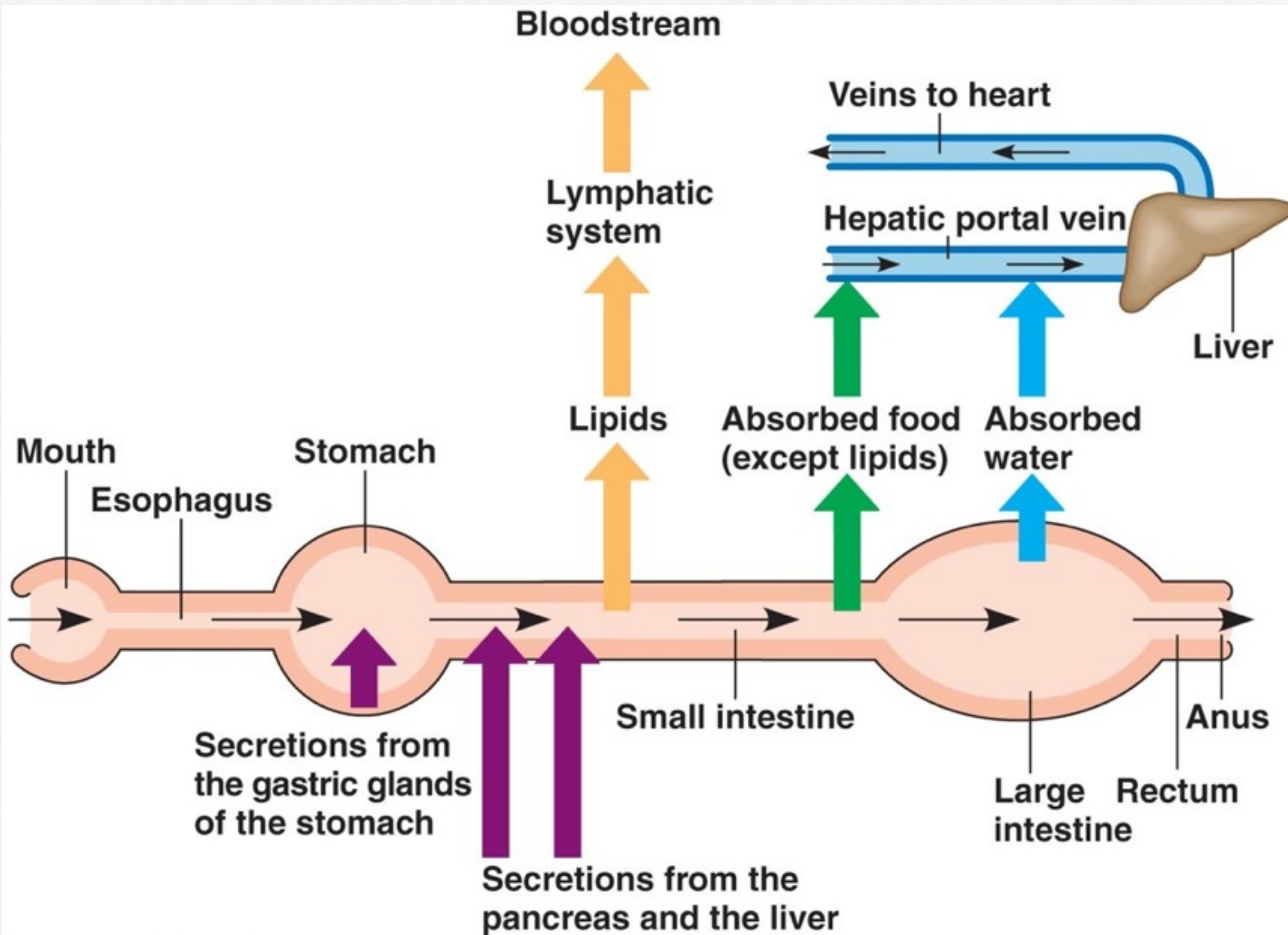


Absorption



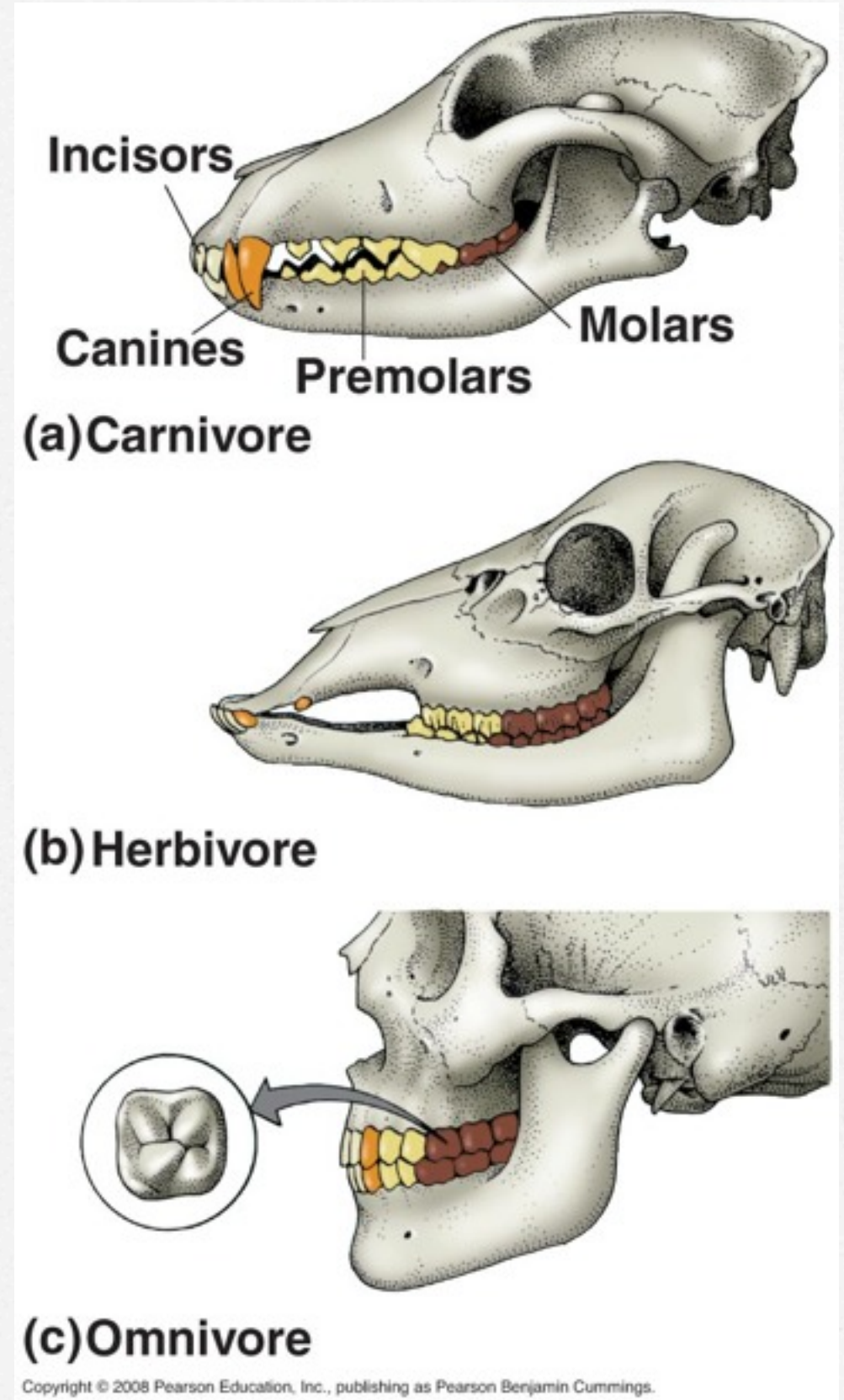
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The absorption can be active or passive depending the nutrient



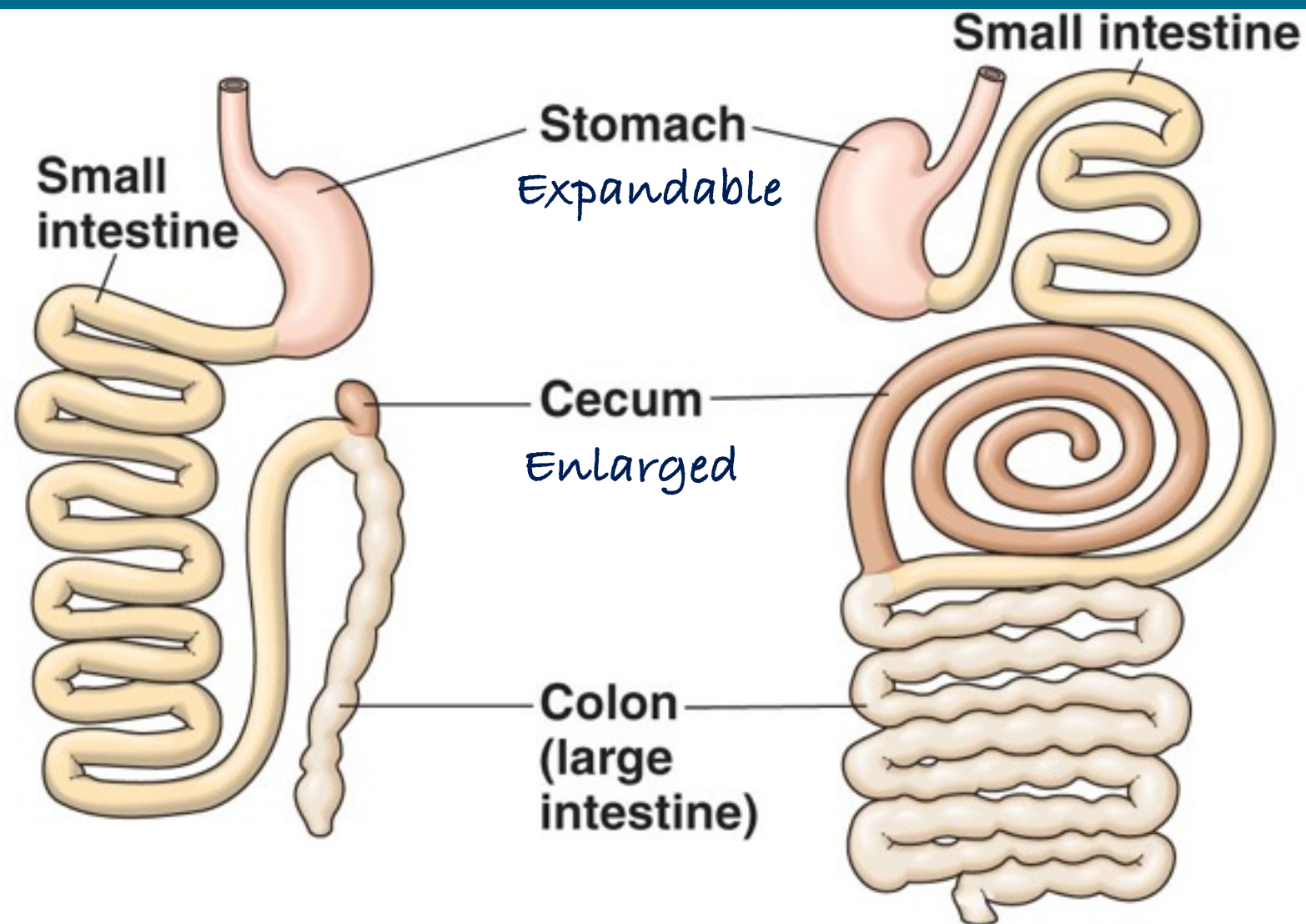
Evolutionary Adaptations

- ❑ **Dental Adaptations**
- ❑ **Stomach Adaptations**
- ❑ **Intestinal Adaptations**
- ❑ **Mutualistic Adaptations**

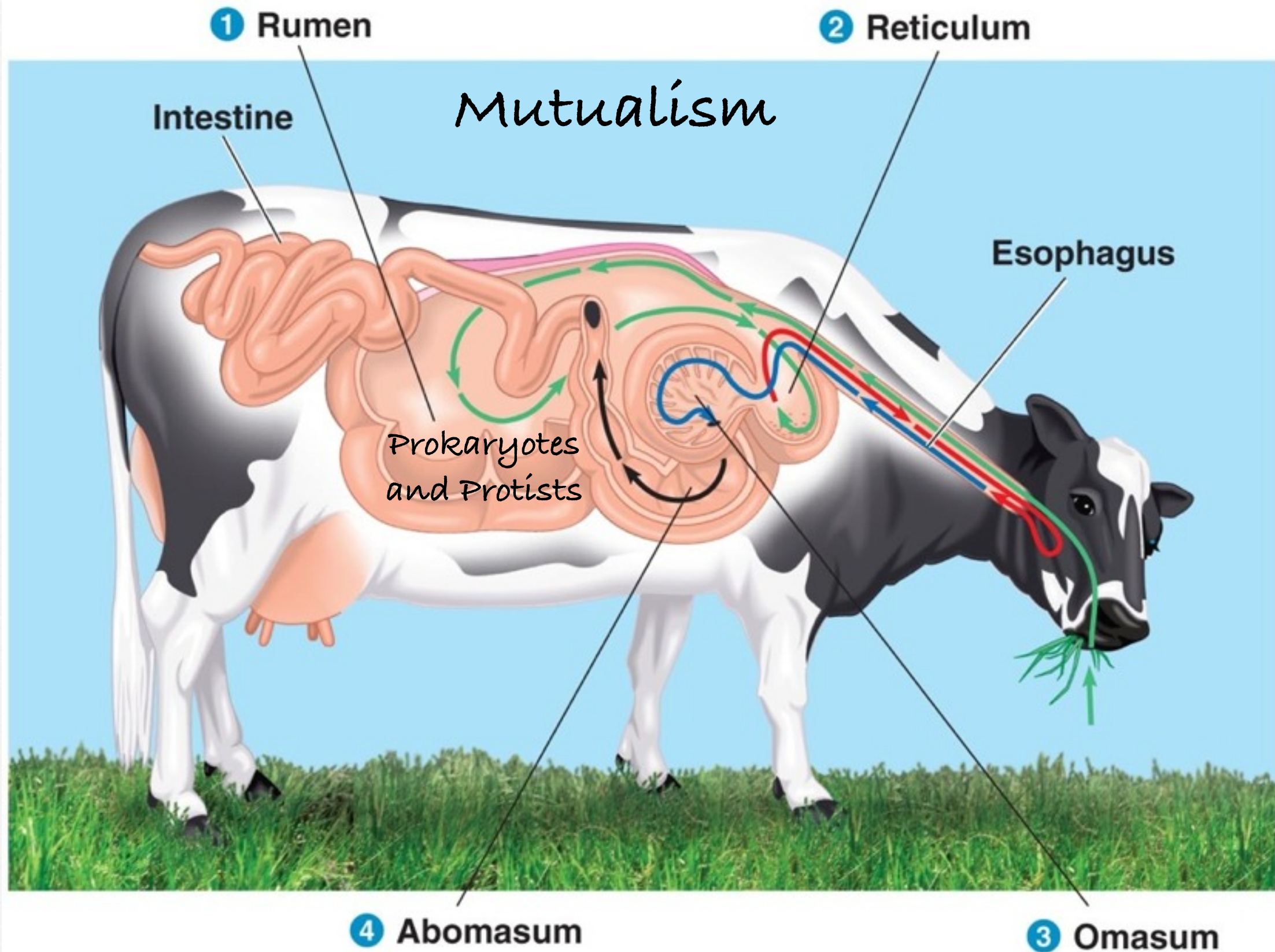


Which digestive tract belongs to the carnivore, the herbivore?

Shorter



Longer



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Plants

Nutritional Requirements

Phototrophs

- ❑ Plants must acquire 17 essential elements
- ❑ Plants do not have to eat, but they must acquire the essential elements so that they make their own "food"
- ❑ Plants carry out **photosynthesis**... a process that uses sunlight and CO_2 to make their own sugars (organic compounds)
- ❑ No process is more important than photosynthesis to the welfare of life on earth.

Nutritional Needs

- ❑ Plants produce sugars (organic molecules) that provide **energy** and **building blocks** not only for themselves but for most the food webs above them.
- ❑ These macromolecules provide the energy for cellular respiration and provide the raw materials for biosynthesis
- ❑ In addition plants require certain specific **essential micro-elements** usually needed in much smaller amounts

Essential Nutrients

- Plants require 2 classes of essential nutrients
 - **MACRO-ELEMENTS**
 - **MICRO-ELEMENTS**
- Plants acquire 3 essential elements from the air and the remaining 14 from the soil.

Table 37.1 Essential Elements in Plants

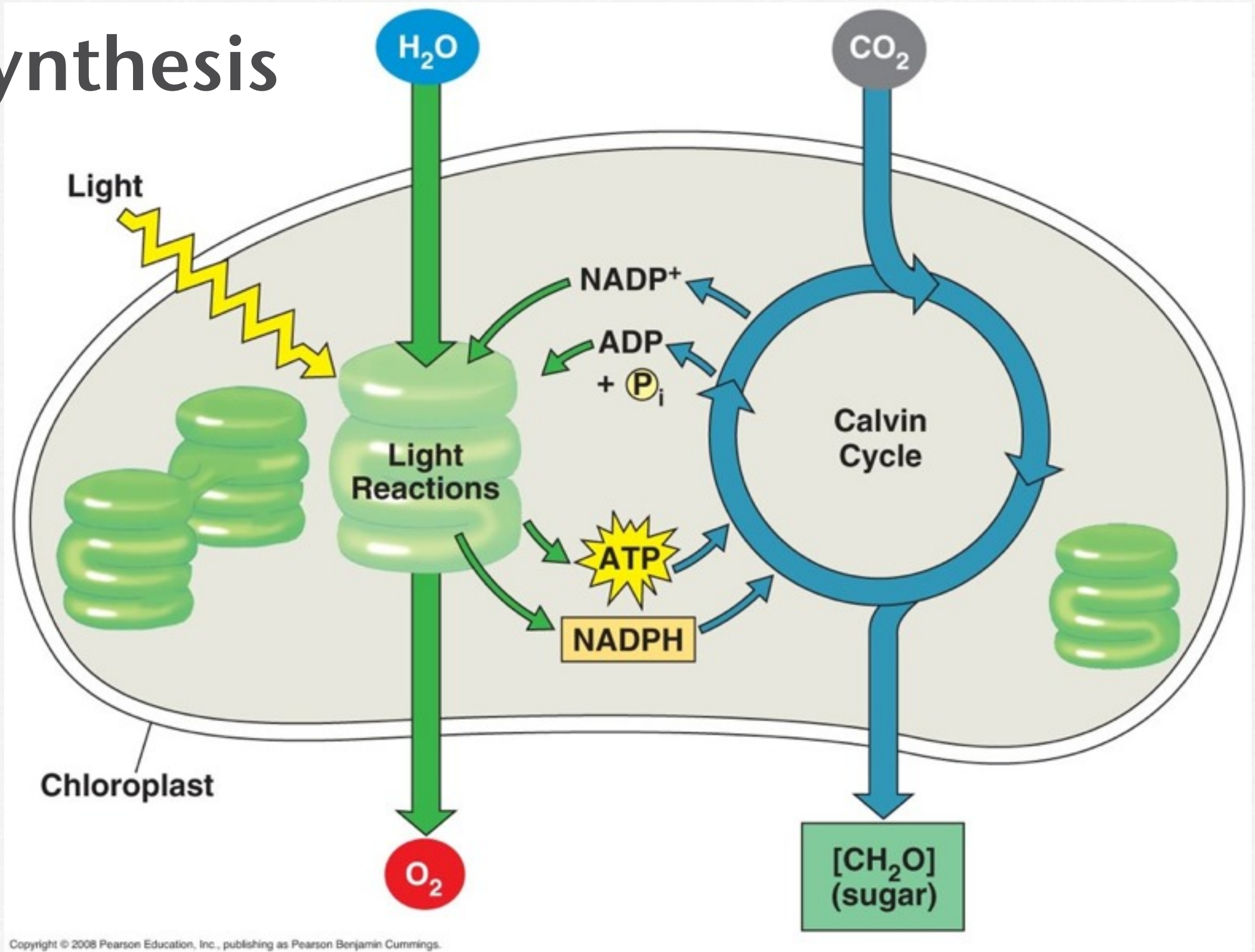
Element	Form Available to Plants	% Mass in Dry Tissue	Major Functions
Macronutrients			
Carbon	CO ₂	45%	Major component of plant's organic compounds
Oxygen	CO ₂	45%	Major component of plant's organic compounds
Hydrogen	H ₂ O	6%	Major component of plant's organic compounds
Nitrogen	NO ₃ ⁻ , NH ₄ ⁺	1.5%	Component of nucleic acids, proteins, hormones, chlorophyll, coenzymes
Potassium	K ⁺	1.0%	Cofactor that functions in protein synthesis; major solute functioning in water balance; operation of stomata
Calcium	Ca ²⁺	0.5%	Important in formation and stability of cell walls and in maintenance of membrane structure and permeability; activates some enzymes; regulates many responses of cells to stimuli
Magnesium	Mg ²⁺	0.2%	Component of chlorophyll; activates many enzymes
Phosphorus	H ₂ PO ₄ ⁻ , HPO ₄ ²⁻	0.2%	Component of nucleic acids, phospholipids, ATP, several coenzymes
Sulfur	SO ₄ ²⁻	0.1%	Component of proteins, coenzymes
Micronutrients			
Chlorine	Cl ⁻	0.01%	Required for water-splitting step of photosynthesis; functions in water balance
Iron	Fe ³⁺ , Fe ²⁺	0.01%	Component of cytochromes; activates some enzymes
Manganese	Mn ²⁺	0.005%	Active in formation of amino acids; activates some enzymes; required for water-splitting step of photosynthesis
Boron	H ₂ BO ₃ ⁻	0.002%	Cofactor in chlorophyll synthesis; may be involved in carbohydrate transport and nucleic acid synthesis; role in cell wall function
Zinc	Zn ²⁺	0.002%	Active in formation of chlorophyll; activates some enzymes
Copper	Cu ⁺ , Cu ²⁺	0.001%	Component of many redox and lignin-biosynthetic enzymes
Nickel	Ni ²⁺	0.001%	Cofactor for an enzyme functioning in nitrogen metabolism
Molybdenum	MoO ₄ ²⁻	0.0001%	Essential for symbiotic relationship with nitrogen-fixing bacteria; cofactor in nitrate reduction

Plants

Nutritional Processing

Photosynthesis

addresses
the energy
demand



Evolutionary Adaptations

- ❑ **Mutualistic Adaptations**
- ❑ **Unusual Feeding Adaptations**
- ❑ **Many other adaptations exist but will be addressed at a later date**



Nodules

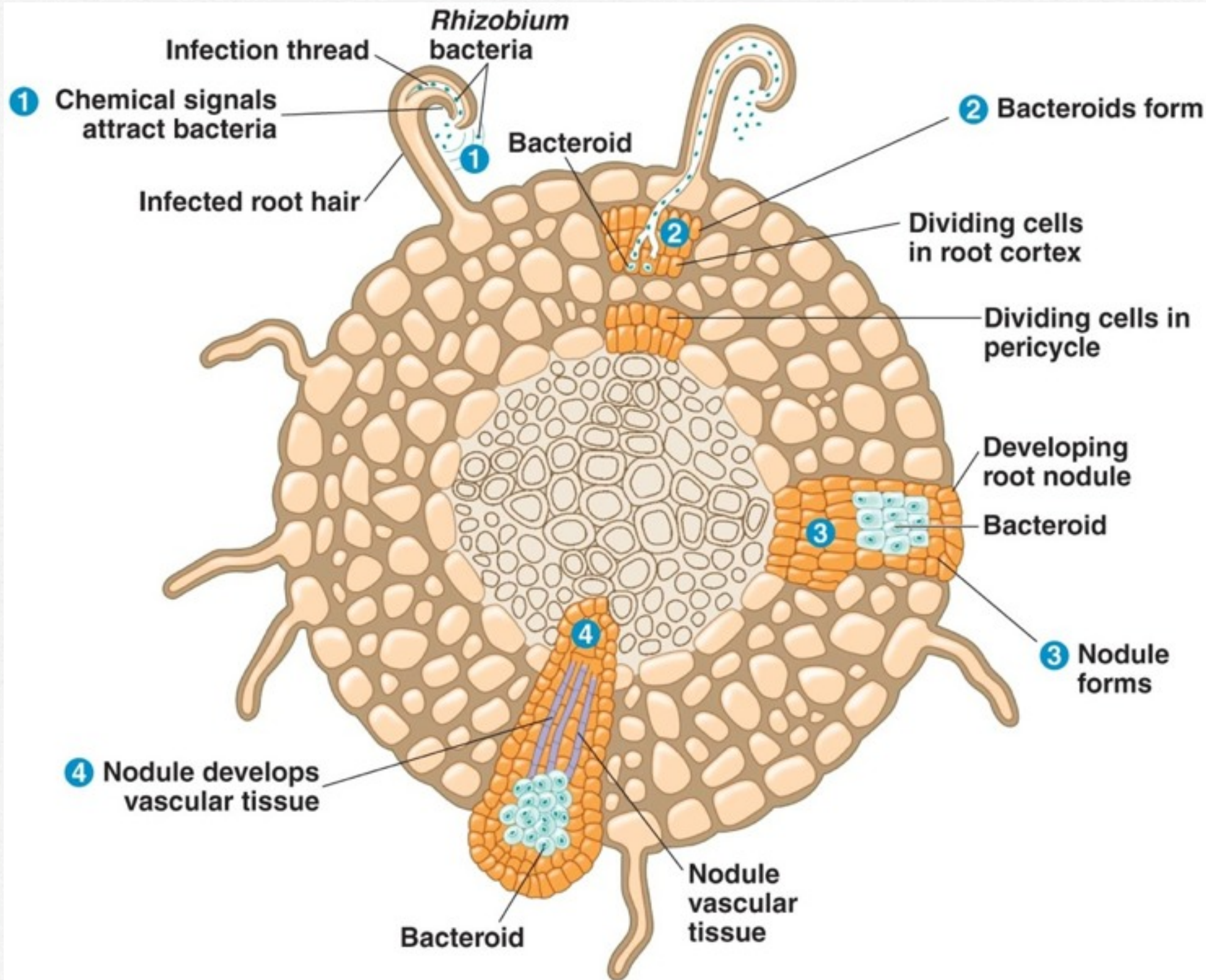
Roots

(a) Pea plant root

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Root Nodules

Plants
&
Prokaryotes



Plant provides
sugar to the
bacteria

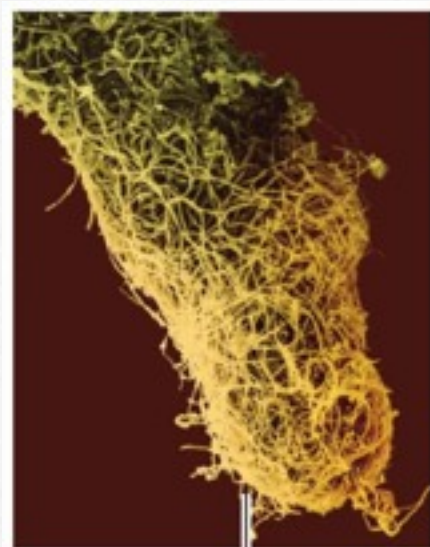


Bacteria
provides
nitrogen to
the plant

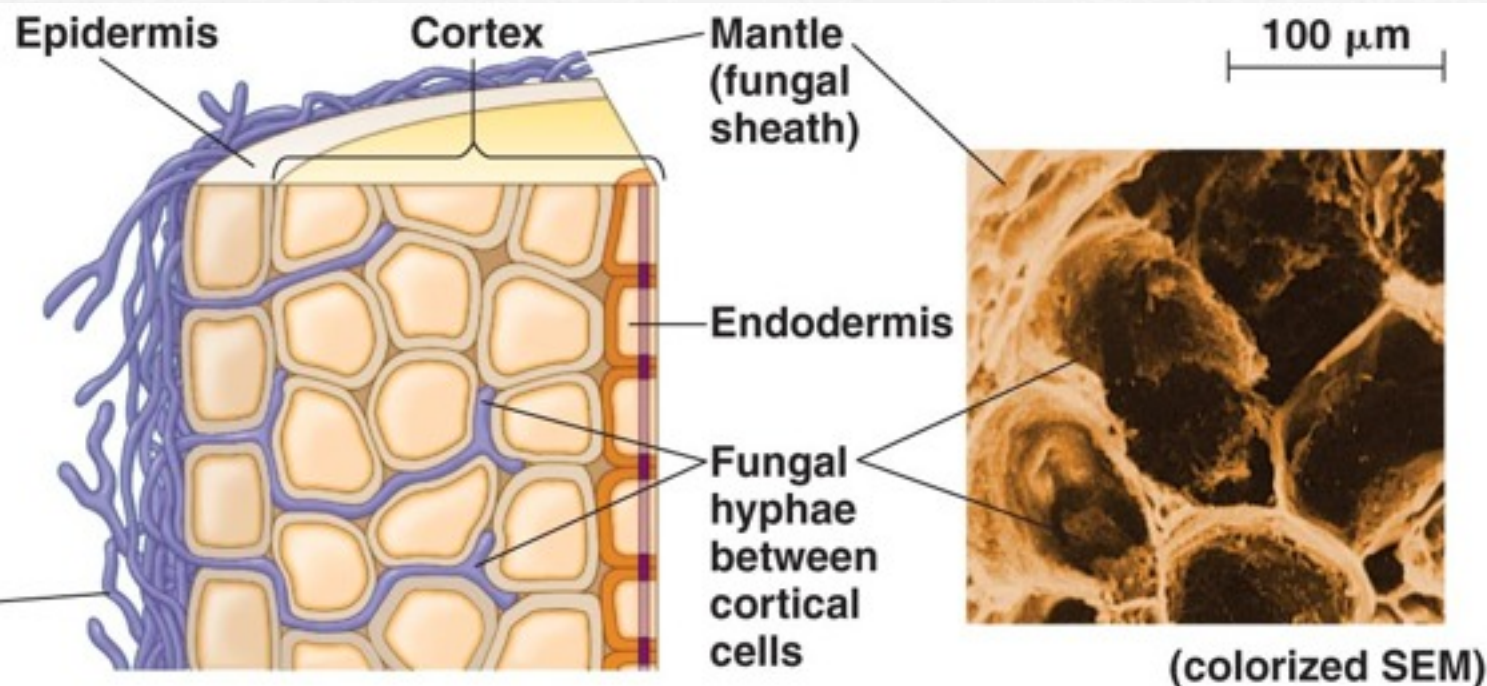


Mycorrhizae

Plants
&
Fungi



Mantle
(fungal sheath)

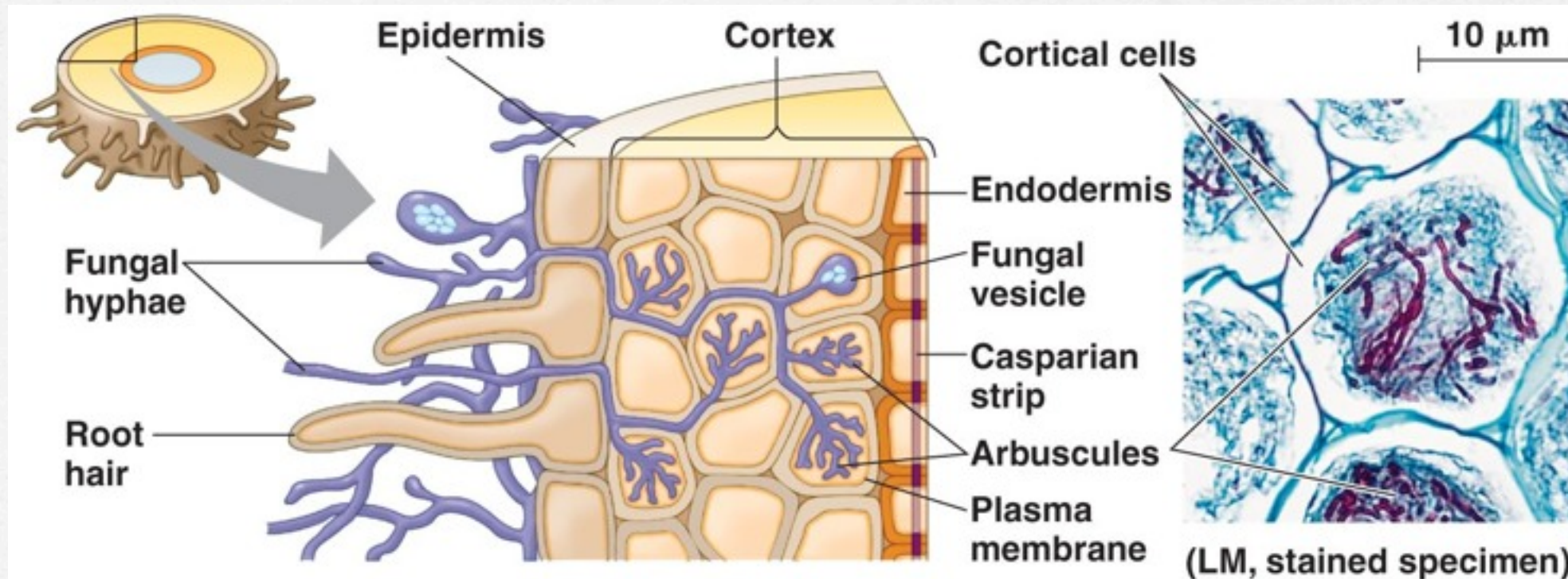


(a) Ectomycorrhizae

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Plant
provides
sugar to
the fungi

Fungi
provides
water to
the plant



(b) Arbuscular mycorrhizae (endomycorrhizae)

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Epiphytes



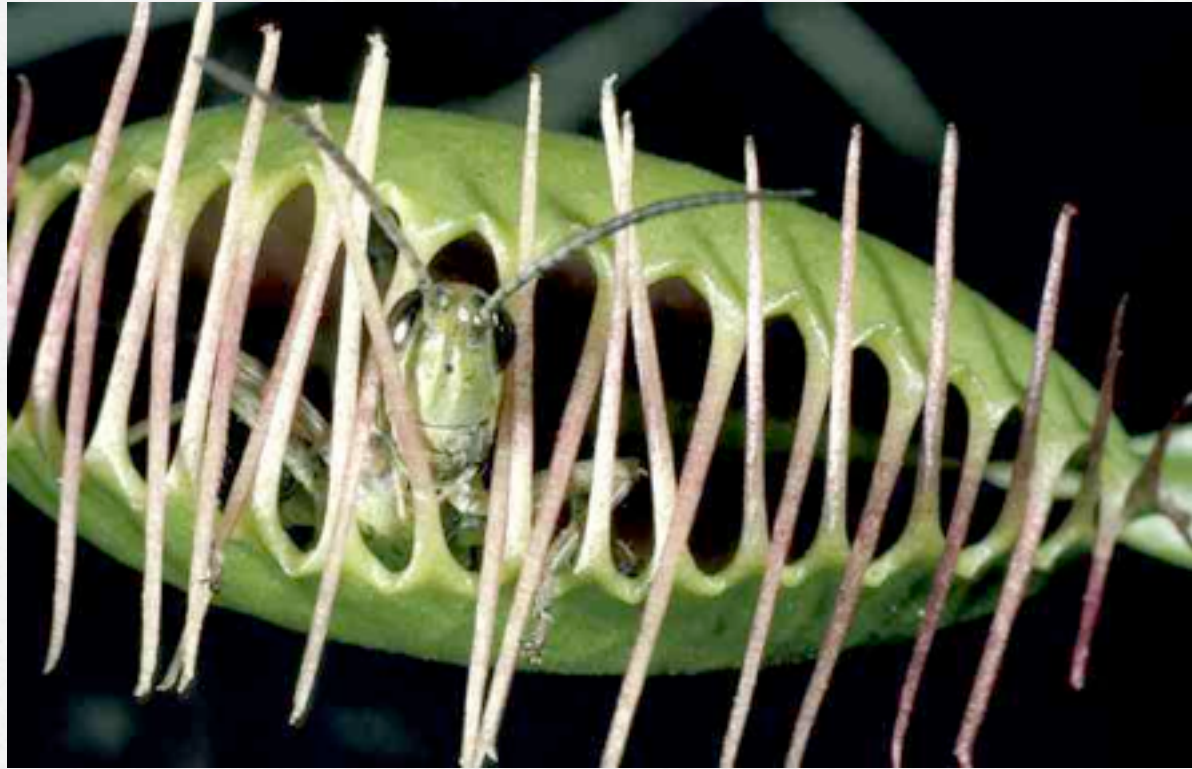
Staghorn Fern



Parasitic Plants



Carnivorous Plants



Pitcher Plant



Venus Fly Trap

Fungi

Nutritional Requirements

Heterotrophs

- ❑ Fungi must acquire the 17 essential elements
- ❑ Fungi have to eat, they can not make their own "food"
- ❑ Fungi **digest their "food" outside their body** and then absorb the sugars and organic compounds from their environment
- ❑ Fungi are **decomposers**, they are very important in an ecological standpoint because they **recycle matter** in ecosystems.

Nutritional Needs

- ❑ Fungi must acquire sugars (organic molecules) that provide **energy** and **building blocks**.
- ❑ These macromolecules provide the energy for cellular respiration and provide the raw materials for biosynthesis
- ❑ In addition fungi require certain specific **essential nutrients** usually needed in much smaller amounts

Essential Nutrients

- Fungi require 2 classes of essential elements
- **MACRO-ELEMENTS**
- **MICRO-ELEMENTS**



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Essential Mineral Nutrients of Fungi

Table 1. Essential Mineral Nutrients of Fungi

Element	Utilizable Form	Concentration (M)	Functions and Comment
Macronutrients			
Potassium	KCl, K ₂ HPO ₄	10 ⁻³	Enzyme activity; carbohydrate metabolism; ionic balance
Phosphorus	KH ₂ PO ₄	10 ⁻³	Nucleic acids; energy transfer; intermediary metabolism
Magnesium	MgCl ₂	10 ⁻³	Enzyme activation; ATP metabolism
Nitrogen	NaNO ₃ , NH ₄ Cl	10 ⁻³	Amino acids, nucleotides and vitamins
Sulfur	K ₂ SO ₄	10 ⁻⁴	Amino acids, vitamins and other sulfhydryl compounds
Calcium	CaCl ₂	10 ⁻⁴	Enzyme activity, membrane structure; not universally required
Micronutrients			
Iron	FeCl ₃ , FeSO ₄	10 ⁻⁶	Cytochromes and heme apoenzymes; pigments
Copper	CuSO ₄	10 ⁻⁶ -10 ⁻⁷	Enzyme activity; pigments
Manganese	MnCl ₂	10 ⁻⁷	Enzyme activity; TCA cycle, nucleic acid synthesis
Zinc	ZnCl ₂	10 ⁻⁸	Enzyme activity; organic acid and other intermediary metabolism
Molybdenum	Na ₂ MoO ₄	10 ⁻⁹	Enzyme activity; nitrate metabolism; vitamin B ₁₂

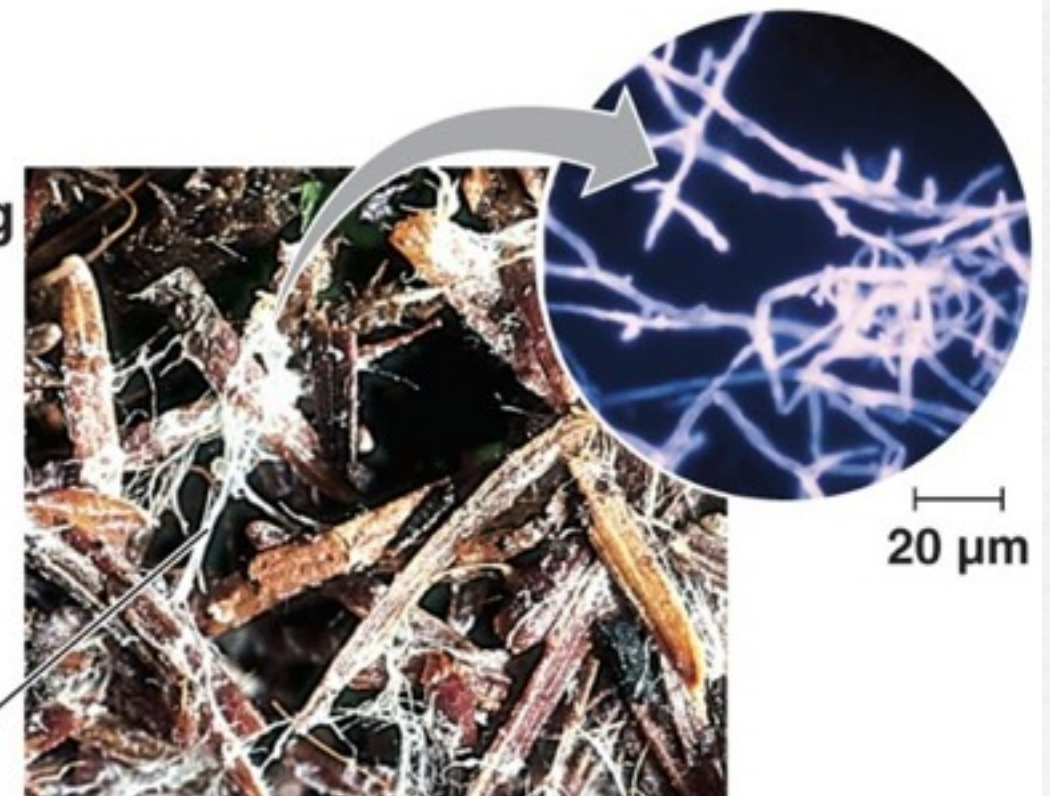
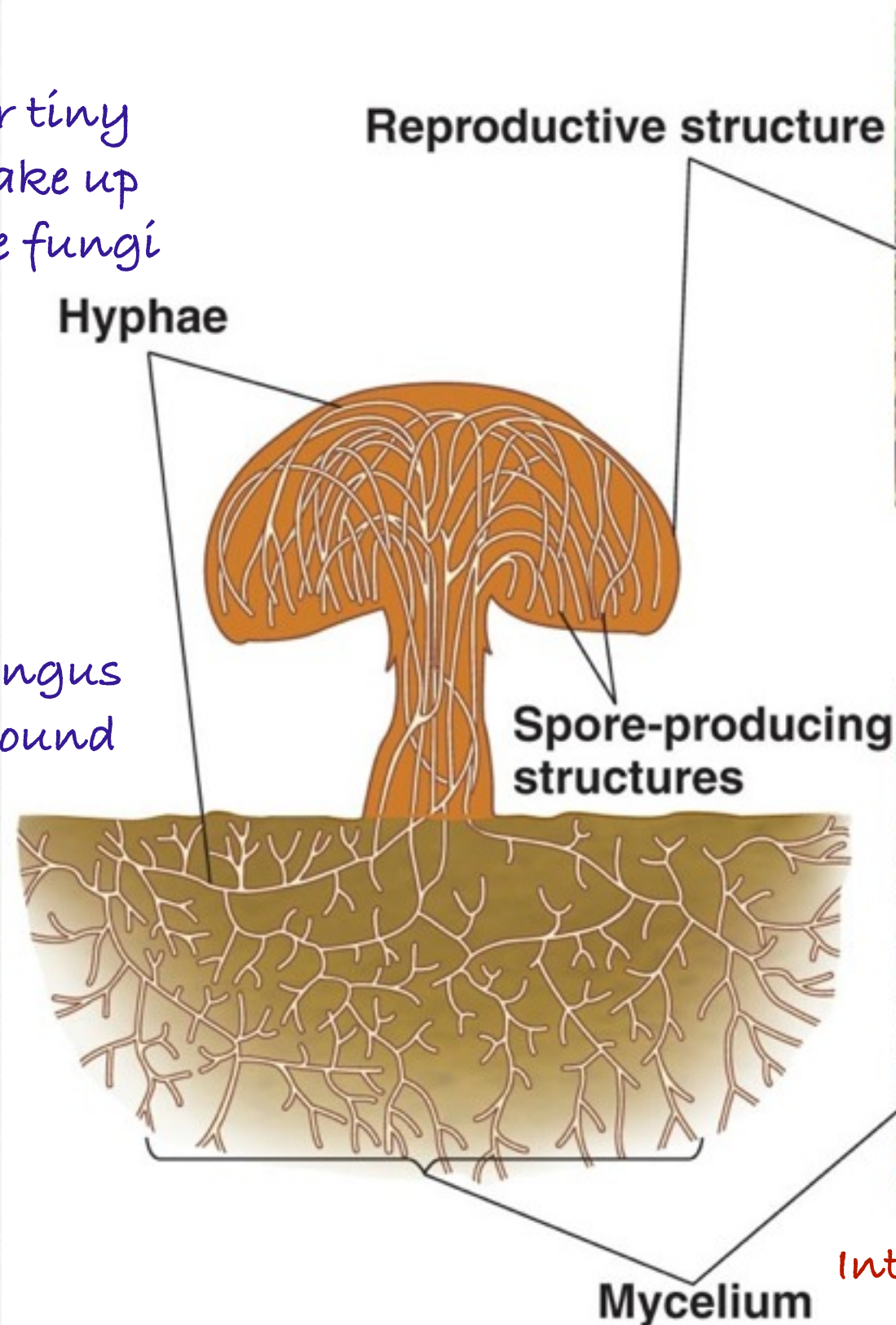
Some evidence suggests that these elements are also essential to fungi Cobalt, Scandium, Vanadium and Gallium

Fungi

Nutritional Processing

Multicellular tiny filaments make up the body of the fungi

Most of the fungus lives underground



Interwoven mass of hyphae, maximizes surface area to volume ratio

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Fungi as Decomposers

- ❑ Fungi can digest and absorb many carbon containing substances: dead organisms, cellulose, jet fuel and house paint.
- ❑ They return all elements back to soil and complete the cycle of matter in ecosystems.
- ❑ Without decomposers like fungi life on earth would not continue.

Fungi as Mutualists

- ❑ Some fungi derive important nutrients from mutualistic relationships between photosynthetic organisms.
- ❑ These relationships often involve fungi providing the water and minerals and the autotroph providing the sugars.

Fungi as Mutualists

- ❑ LICHENS- a mutualistic relationship where fungi provide water and minerals and algae provide sugars
- ❑ MYCORRHIZAE- a mutualistic relationship where a fungi provide water and minerals and plants provide sugars
- ❑ Fungus-gardening insects- leaf cutting ants feed the ants while the fungus digest the cellulose for the ants

▼ A fruticose (shrublike) lichen



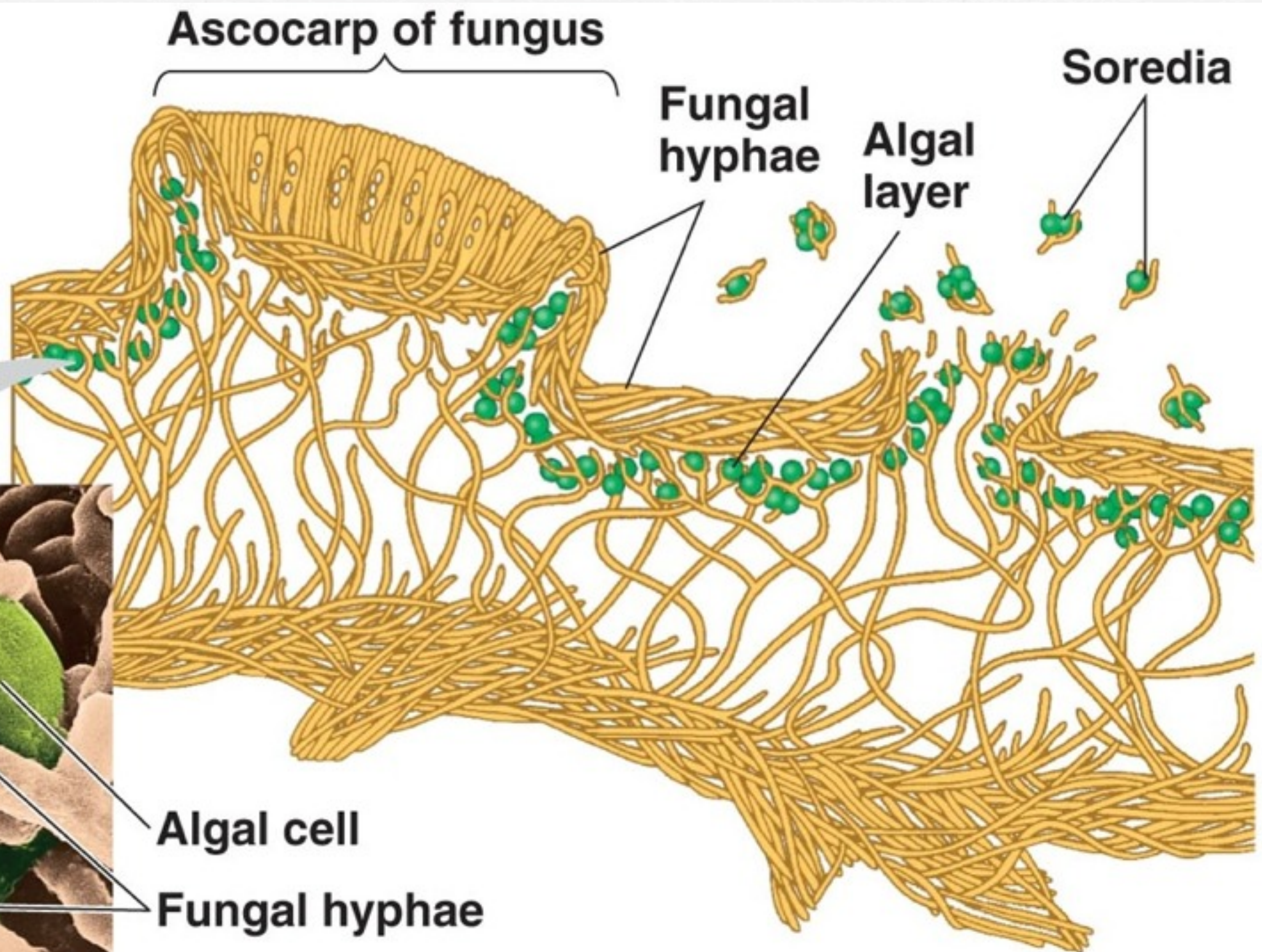
◀ Crustose (encrusting) lichens

▼ A foliose (leaflike) lichen



LICHEN

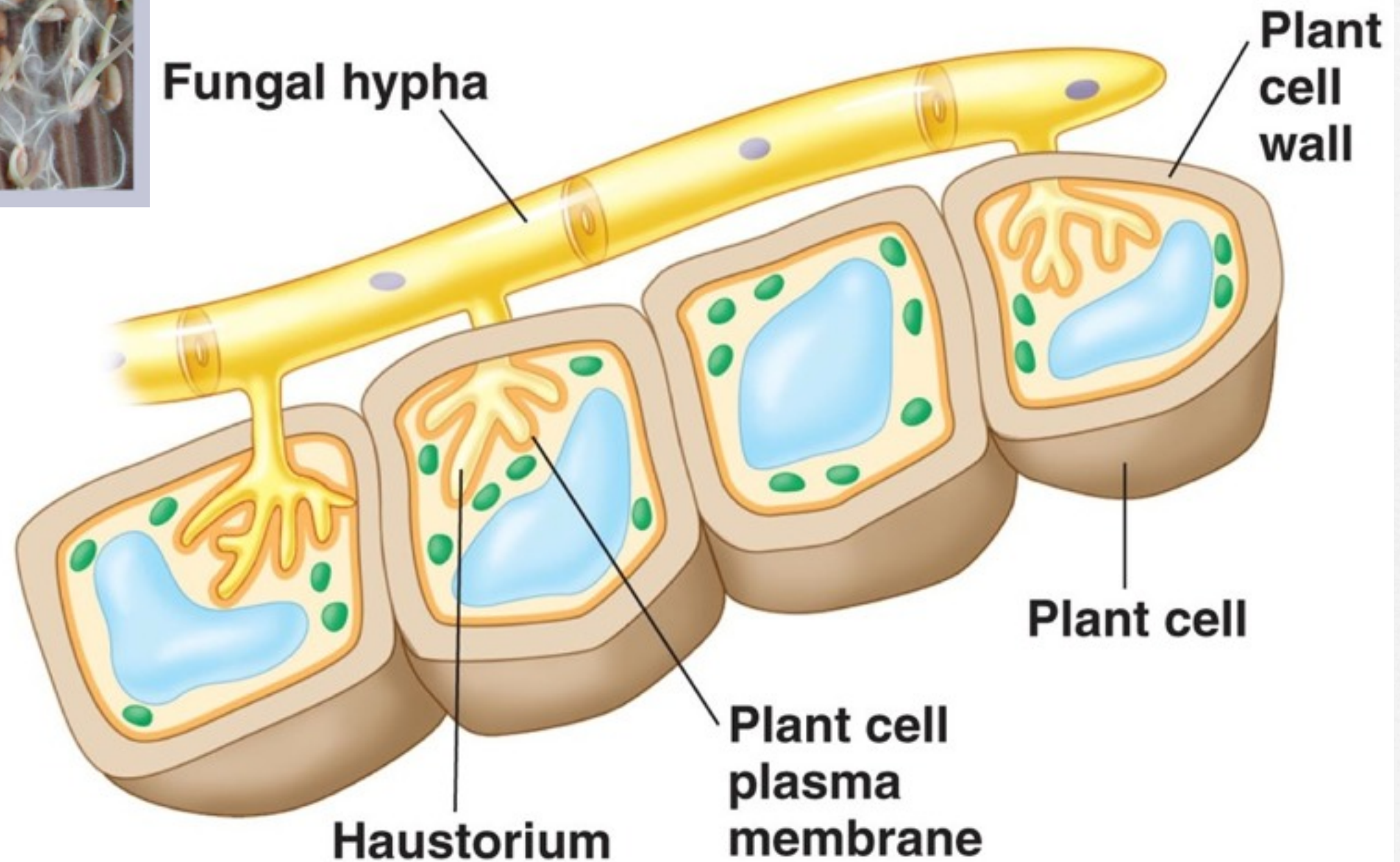
Fungi
&
protist (algae) or
bacteria
(cyanobacteria)



20 μm

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Mycorrhizae



(b) Haustoria

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Fungi as Pathogens

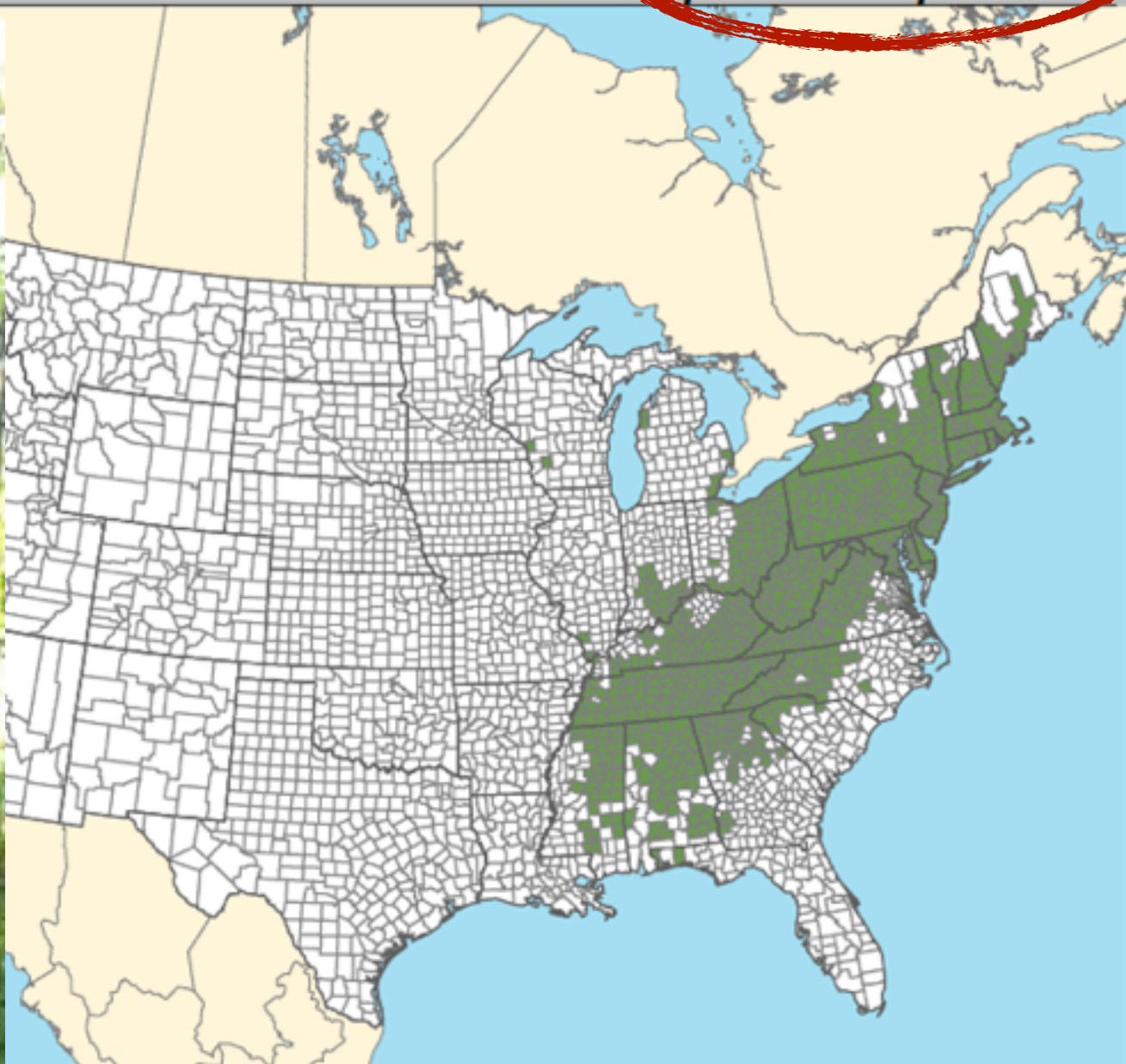
- About 30% of fungi feed from living organisms as parasites or pathogens.
- Mostly affects plants but can also attack animals including humans.



Alien Forest Pest Explorer

www.fs.fed.us/ne/morgantown/4557/AFPE/

Pest Distribution Map
Chestnut Blight
Cryphonectria parasitica



USDA
Forest
Service



Northern
Research
Station



Eastern Forest
Environmental Threat
Assessment Center



Forest Health
Technology
Enterprise Team



Remote Sensing
Applications
Center



Alien Forest Pest Explorer

www.fs.fed.us/ne/morgantown/4557/AFPE/

Pest Distribution Map

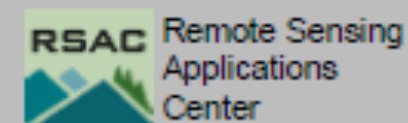
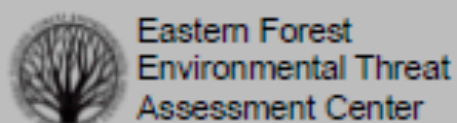
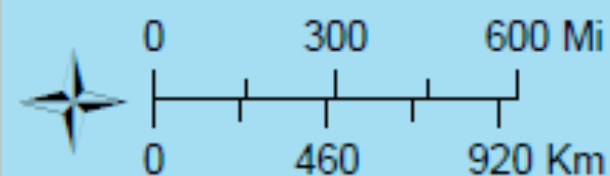
Pitch Canker

Fusarium circinatum

Alaska



● Distribution as of 7/20/2009





(a) Corn smut on corn



**(b) Tar spot fungus on
maple leaves**



(c) Ergots on rye

Rye Ergots



Yeast Infections





Image Courtesy of M. McGinnis
Copyright © 2000 Doctorfungus Corporation

Athletes Foot

Ringworm



Protista

Nutritional Requirements

Nutritional Diversity

- Like all life protists must acquire the 17 essential elements
- How they acquire these essential elements as a group is very diverse...
- Some are **HETEROTROPHS**, some are **AUTOTROPHS** and yet others are **MIXOTROPHS** as they obtain their nutrition or produce it from photosynthesis

Nutritional Needs

- ❑ Protists must acquire sugars (organic molecules) that provide **energy** and **building blocks**.
- ❑ These macromolecules provide the energy for cellular respiration and provide the raw materials for biosynthesis
- ❑ In addition protists require certain specific **essential nutrients** usually needed in much smaller amounts

Protista

Nutritional Processing

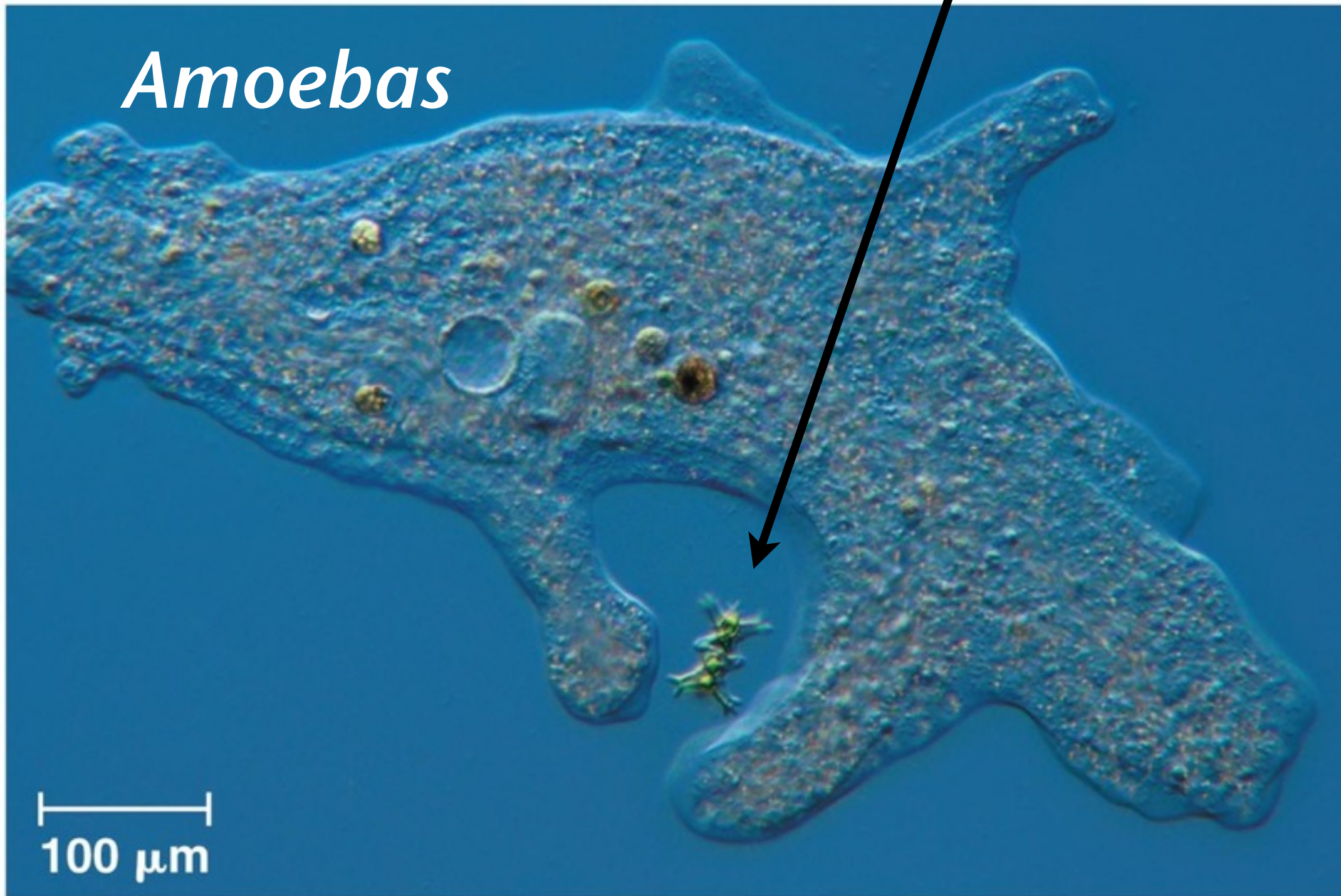
Essential Nutrients

- Protista acquire "food" in one of three ways
 - **ABSORPTION**
 - **INGESTION**
 - **ENGULFING**
- Unless of course, they make their own "food"

Unikonta:

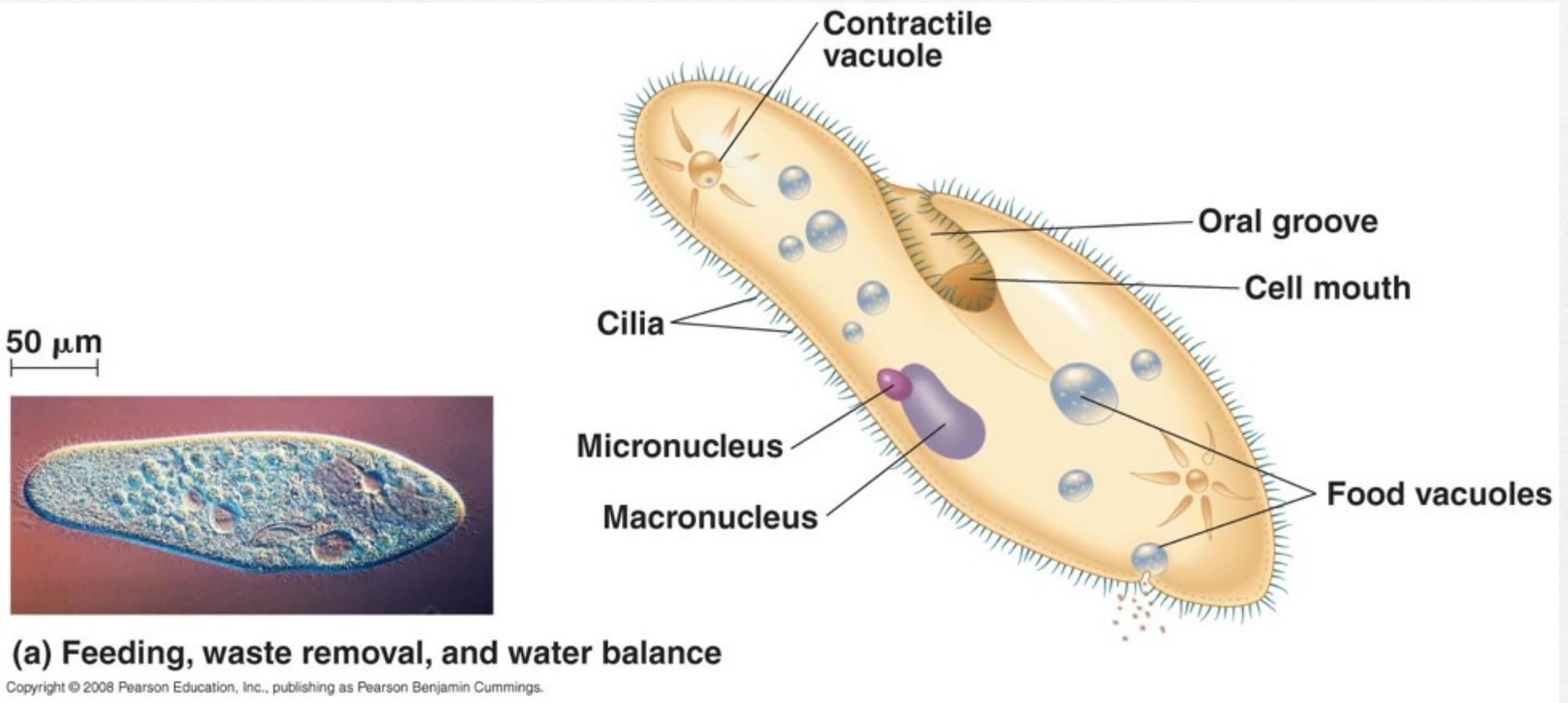
HETEROTROPHIC

Amoebas



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Chromalveolata: *Paramecium*



HETEROTROPHIC

Archaeplastida

Green Algae

AUTOTROPHIC



(a) *Ulva*, or sea lettuce

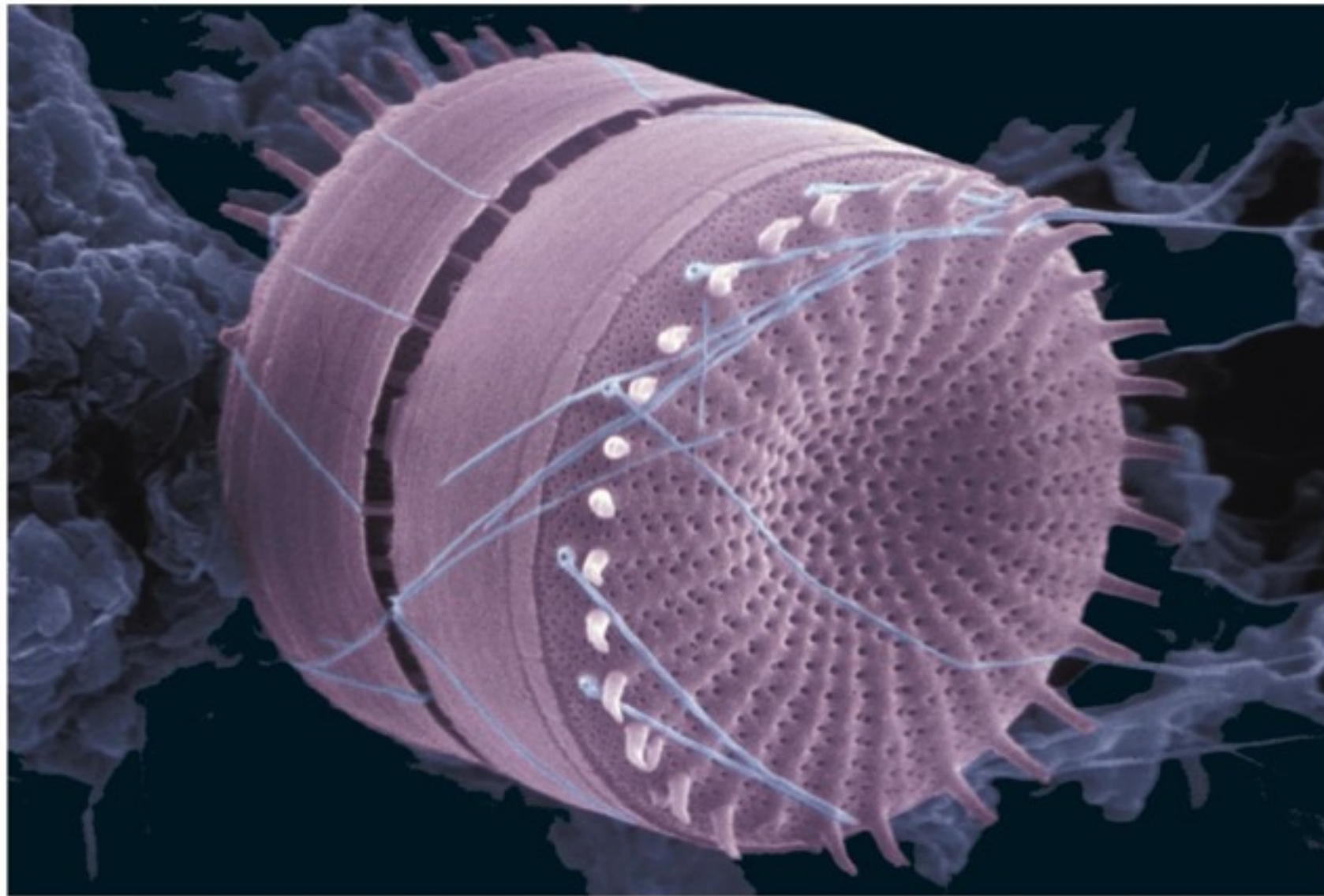
2 cm

(b) *Caulerpa*, an intertidal chlorophyte



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Chromalveolata: *Diatoms*



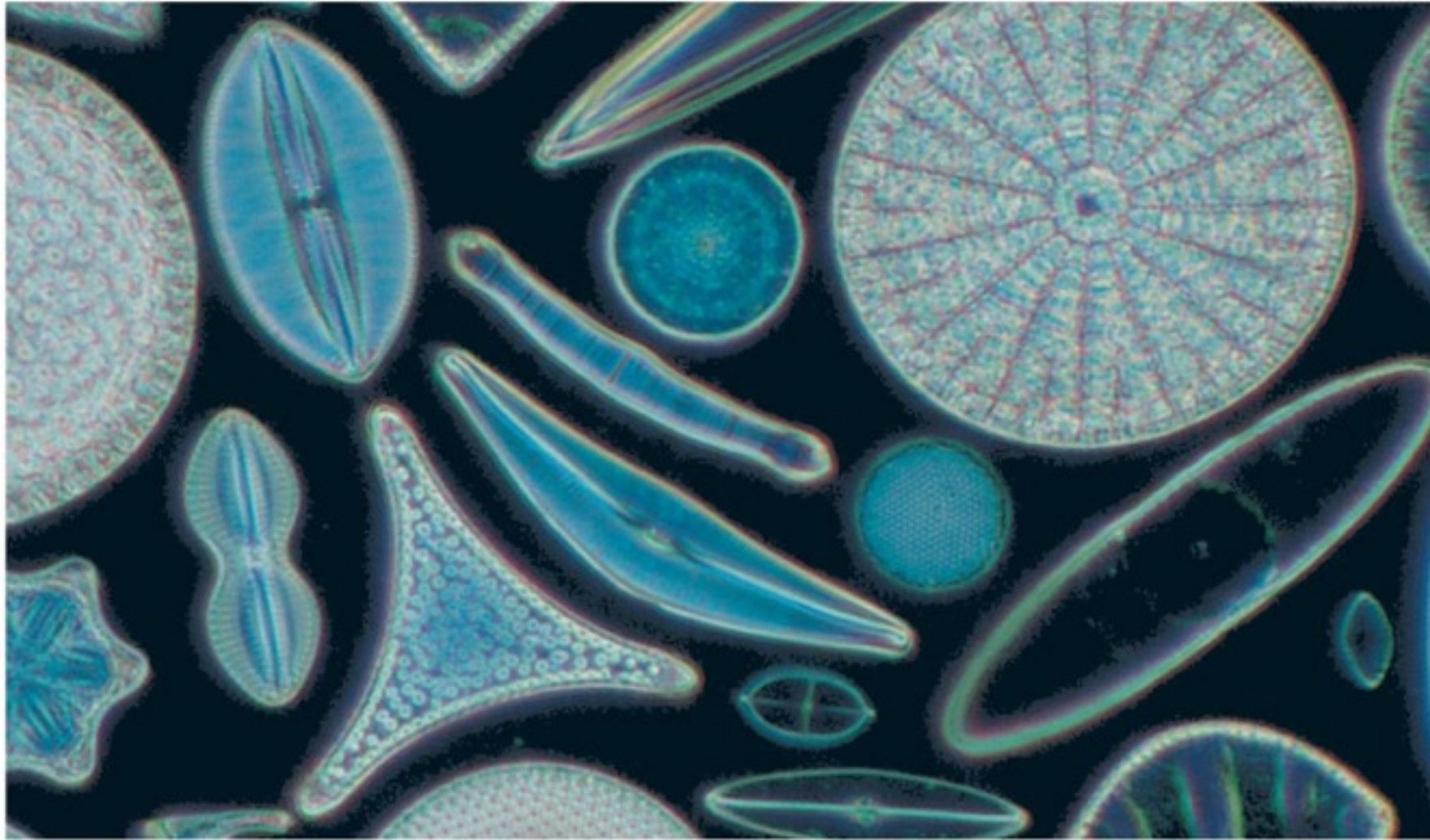
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unicellular algae,
that have a
unique glass-like
wall made of
silicon dioxide
embedded in an
organic matrix

AUTOTROPHIC

Important component of phytoplankton,
one bucket of sea water may contain
millions of diatoms

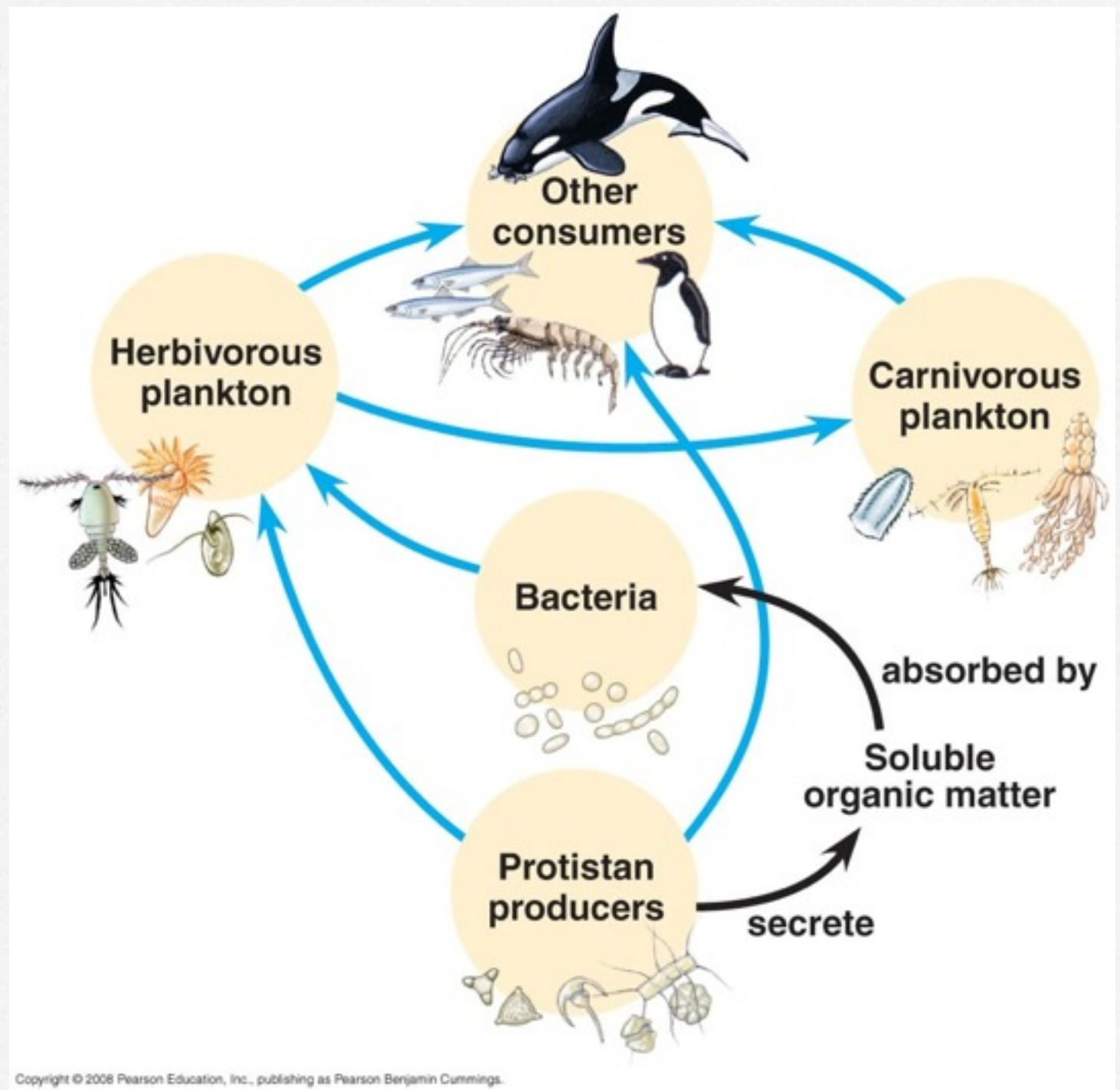
Chromalveolata



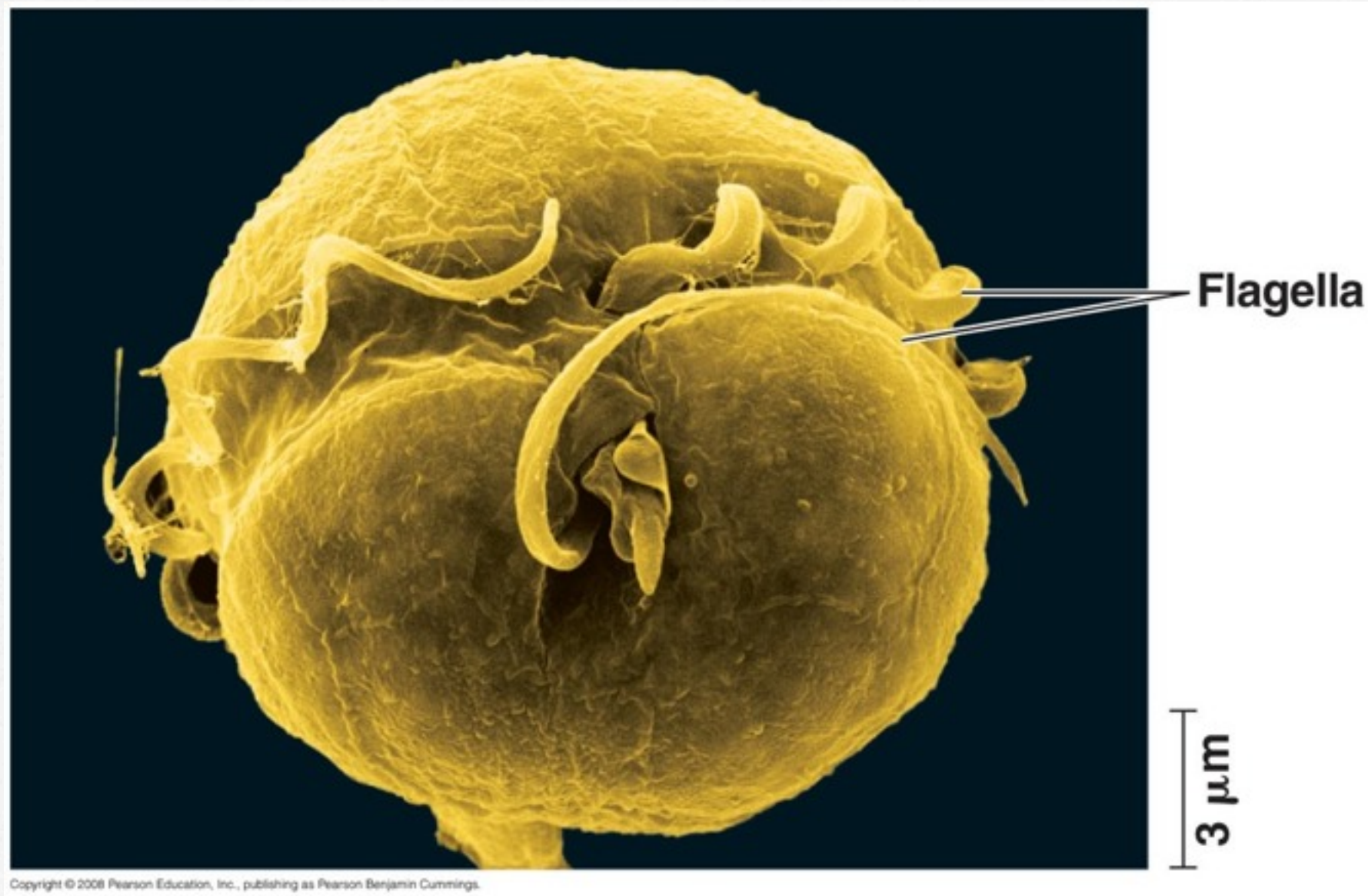
Some of the most important photosynthetic organisms on earth!

Chromalveolata

Scientists estimate that 30% of the world's photosynthesis is performed by diatoms, dinoflagellates, multicellular algae and other aquatic protists



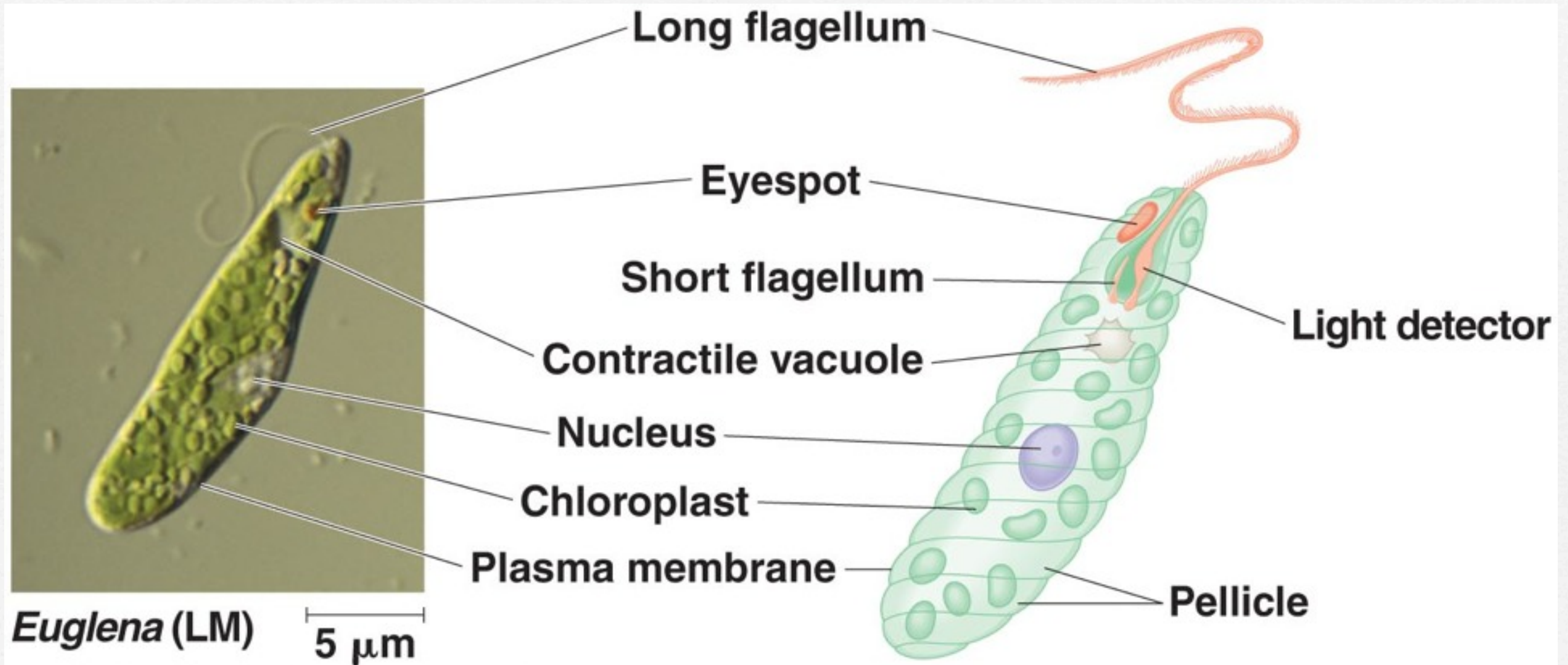
Chromalveolata: *Dinoflagellates*



Important
component of
phytoplankton,
abundant
producers of
aquatic
ecosystems

MIXOTROPHIC

Excavata



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MIXOTROPHIC

Bacteria

Nutritional Requirements

Nutritional Diversity

- Like all life bacteria must acquire the 17 essential elements
- How they acquire these essential elements as a group is very diverse...
- Some are **HETEROTROPHS**, some are **AUTOTROPHS**
- All four nutritional modes are represented in this group

Nutritional Needs

- ❑ Bacteria must acquire sugars (organic molecules) that provide **energy** and **building blocks**.
- ❑ These macromolecules provide the energy for cellular respiration and provide the raw materials for biosynthesis
- ❑ In addition bacteria require certain specific **essential nutrients** usually needed in much smaller amounts

Bacteria

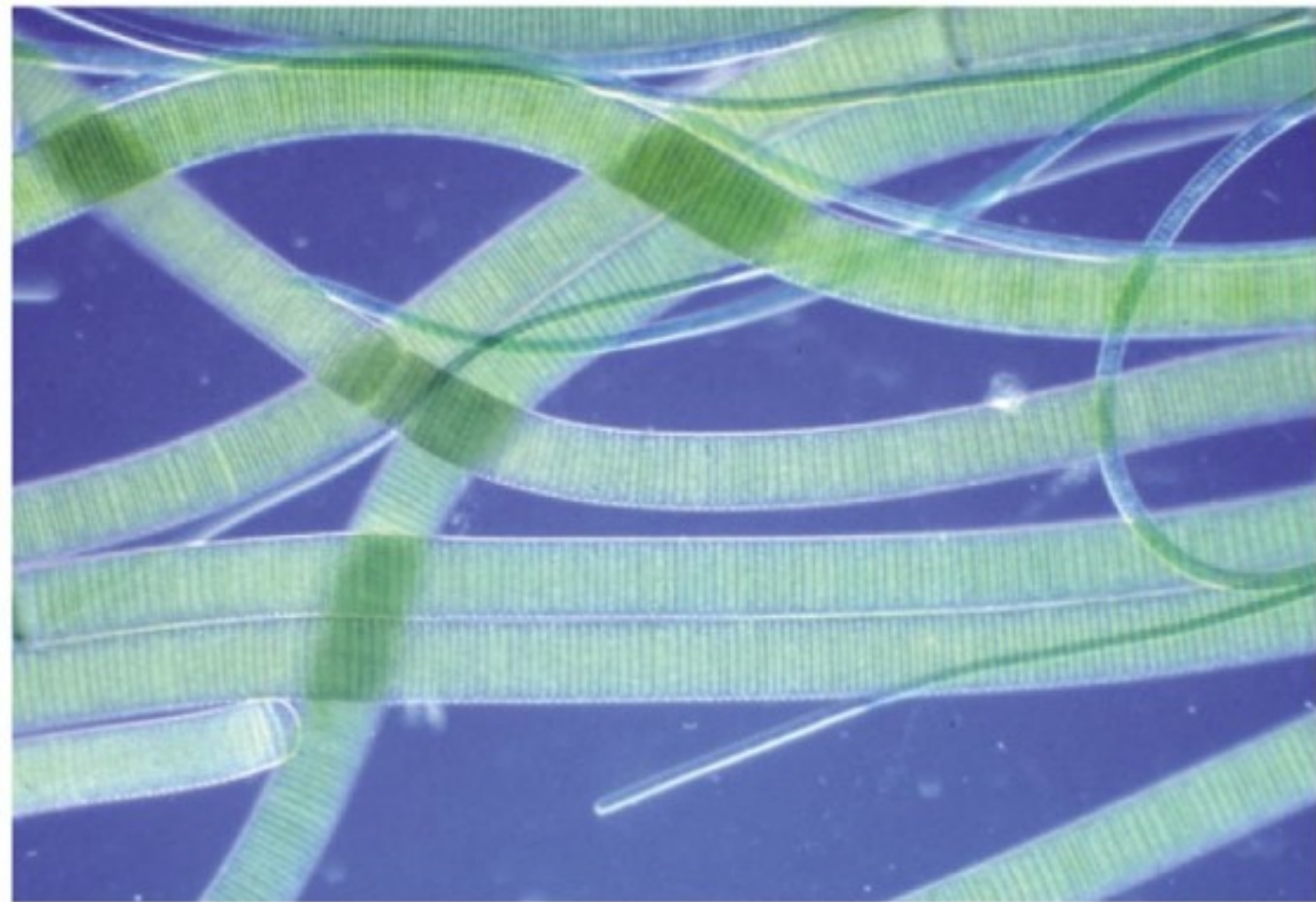
Nutritional Processing

Cyanobacteria

PHOTOAUTOTROPHS

Important
component of
phytoplankton

Some also fix
nitrogen



50 μm

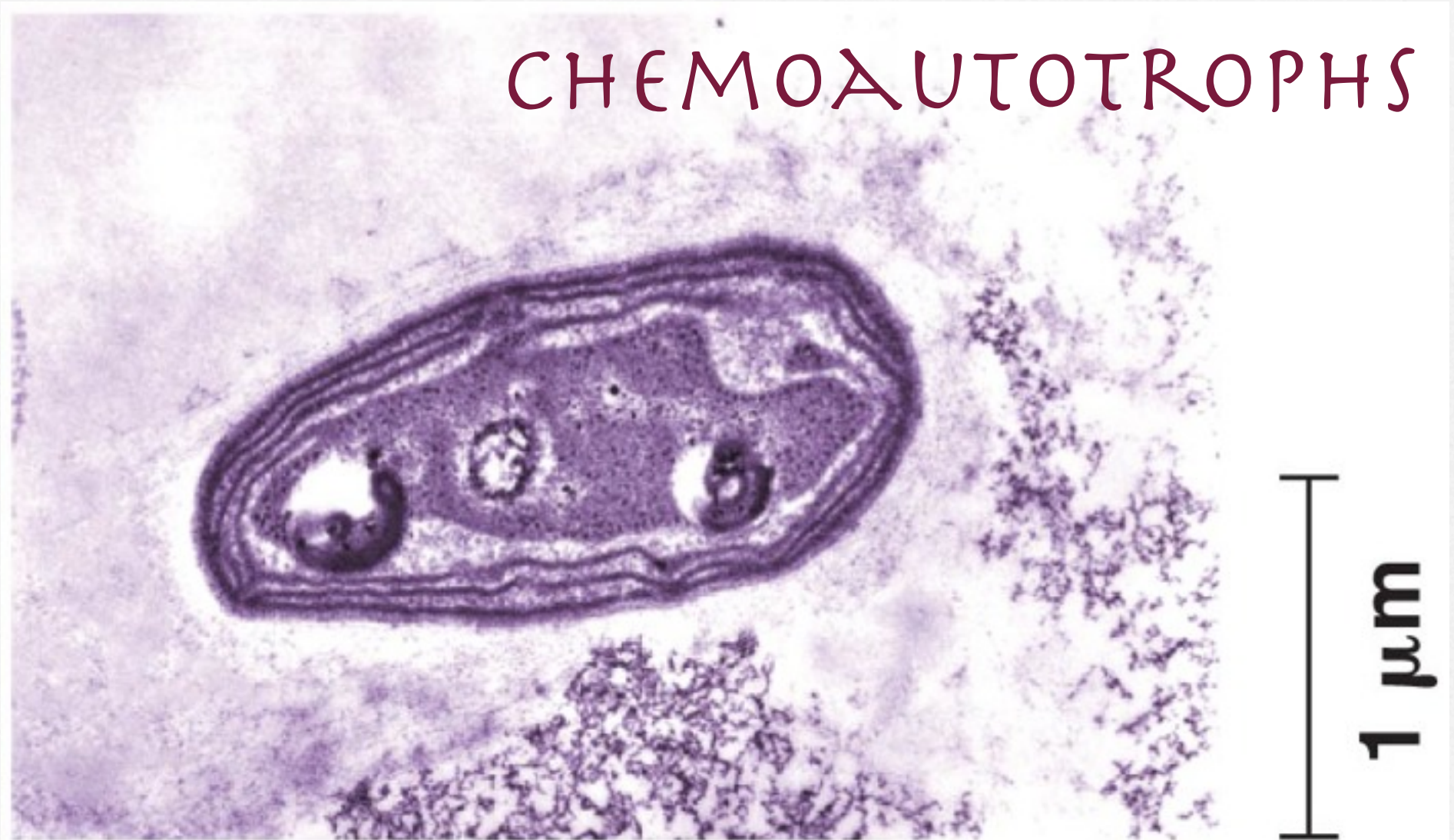
**Two species of *Oscillatoria*,
filamentous cyanobacteria (LM)**

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Beta Proteobacteria

These bacteria acquire energy through nitrogen compounds, they play a key role in the nitrogen cycle.

CHEMOAUTOTROPHS



***Nitrosomonas* (colorized TEM)**

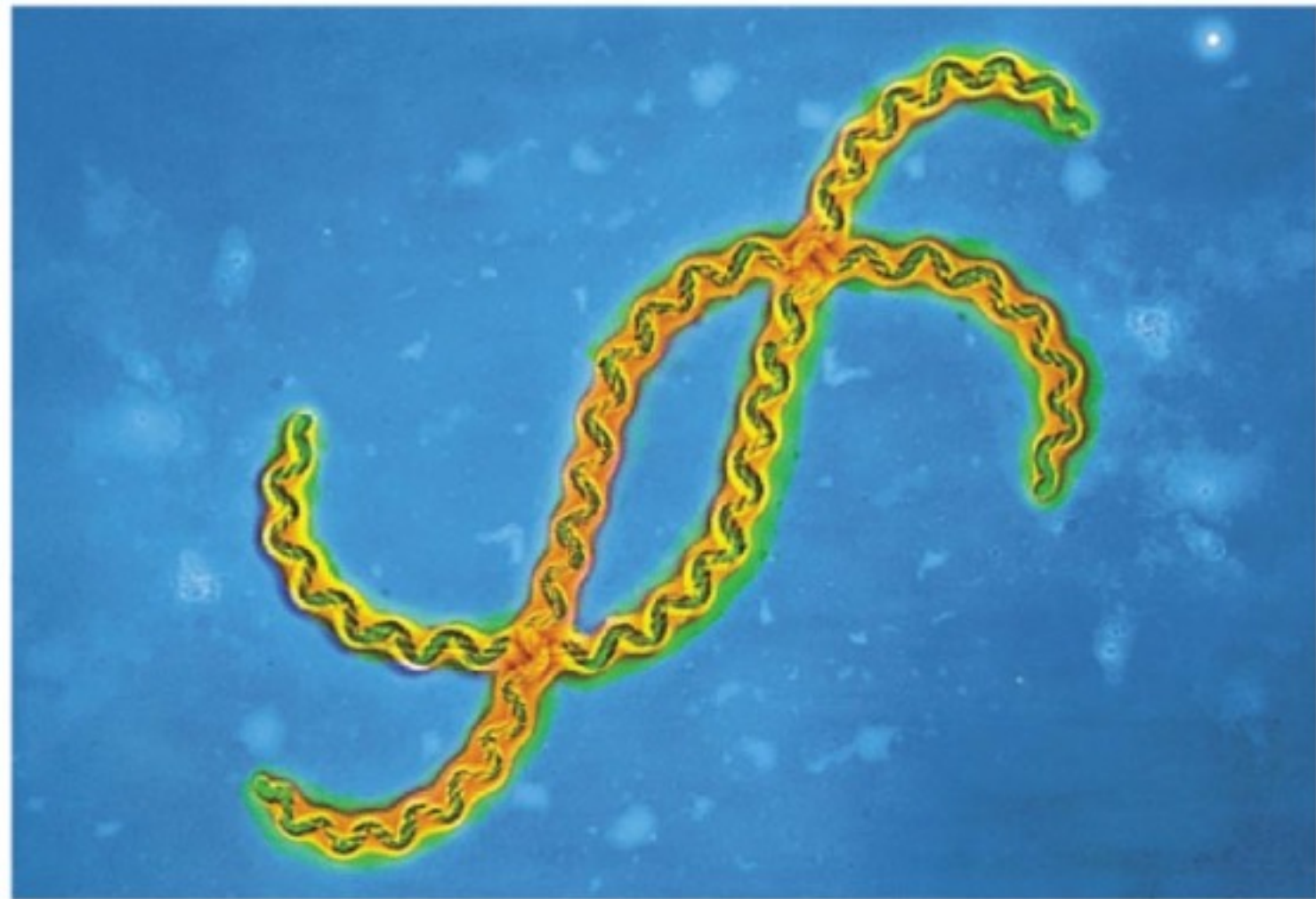
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Spirochetes

HETEROTROPHS

Pathogens

Cause Lyme
Disease &
Syphilis



***Leptospira*, a spirochete
(colorized TEM)**

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Alpha Proteobacteria

Rhizobium

MUTUALISTS

These
bacteria fix
nitrogen for
plants and in
return they
given sugars



2.5 μm

***Rhizobium* (arrows) inside a root cell of a legume (TEM)**

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