Plants Unit

Week 3 – What happens inside plant cells?

Waterford Biology

Plants Unit – W3 Driving Question

- **This week's driving question: What happens inside plant cells?**
- How do plants acquire fat and protein?
- How do plants perform biosynthesis?
- What are enzymes and how do they enable cells to function?

Part 1 Recap

- Earlier we compared the nutrition labels of spinach and peanuts.
- We observed that peanuts have high concentrations of fat and protein.
- How can a plant acquire fat and protein without consuming other organisms?

REMINDERS FROM EARLIER WEEKS

Remember the following "rules" for energy and matter:

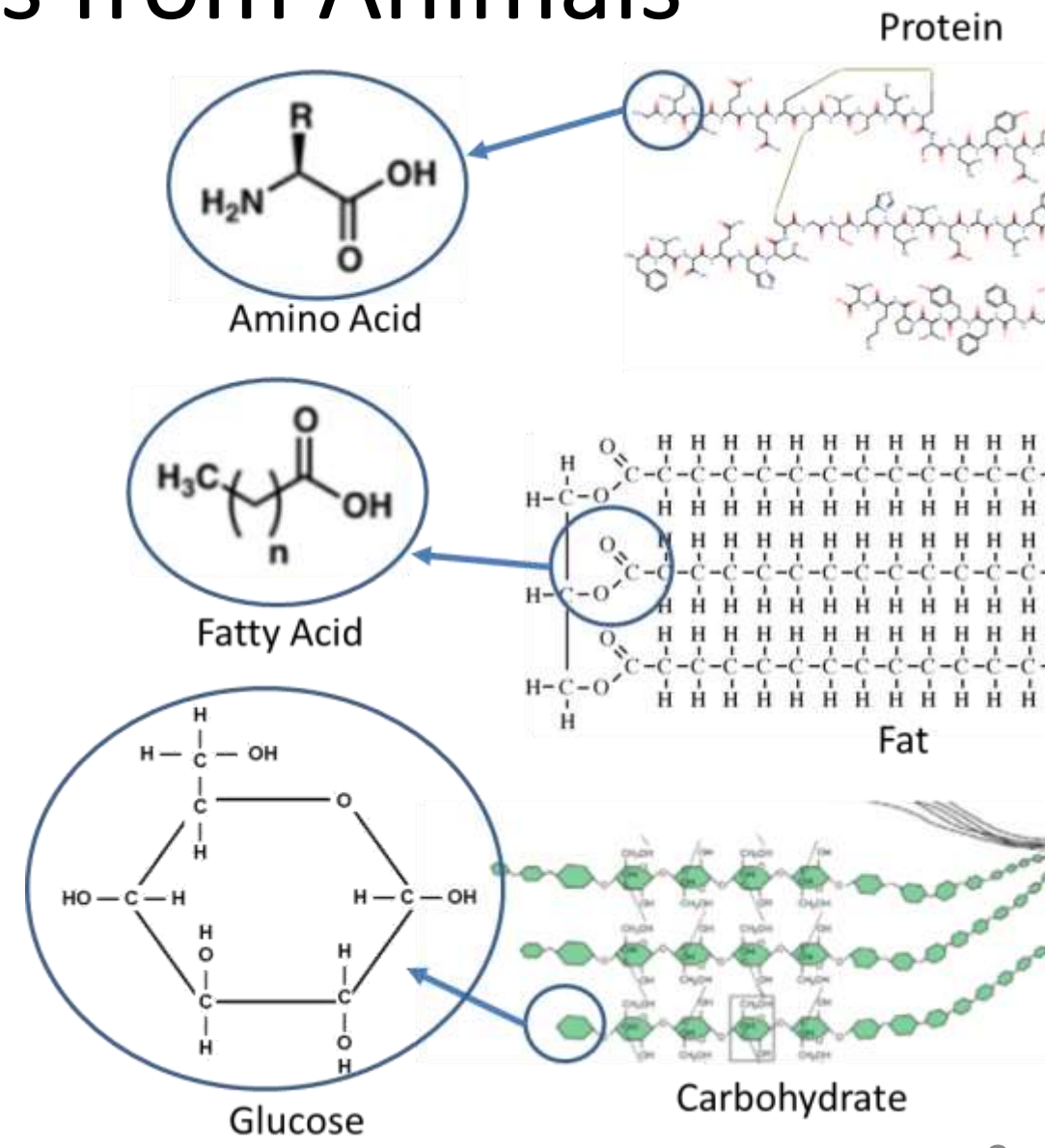
All solids, liquids, and gases are made of atoms.
Multiple atoms can bond together to form molecules.
E.g., water molecules consist of one oxygen atom & two hydrogen atoms.

In biology, **atoms last forever**.
An atom cannot be created or destroyed or turned into energy. *E.g., a carbon atom is always a carbon atom*.
However, atoms can be rearranged to form new molecules.

In biology, **energy lasts forever**.
Energy cannot be created or destroyed.
Energy exists as light, heat, motion, or as chemical energy.
Energy can transform. *E.g., light can transform into heat*.

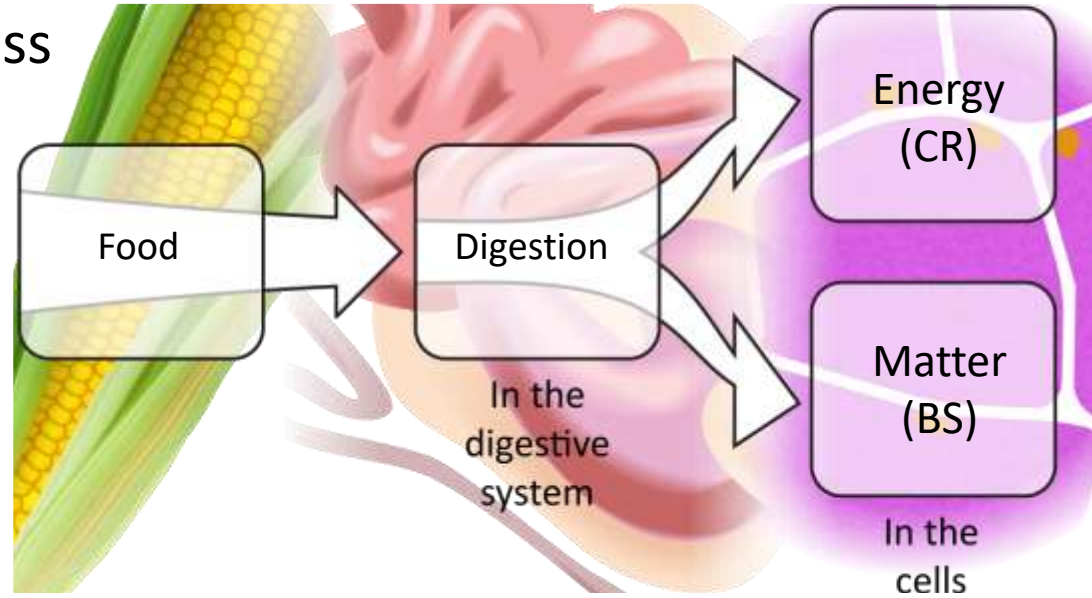
Reminders from Animals

- **A <u>macromolecule</u> is a long chain of individual molecules bonded together.**
  - Macromolecules do all the work of cells.
- **Cells are made from macromolecules.**
  - Cells form tissues, which form organs, which form systems.



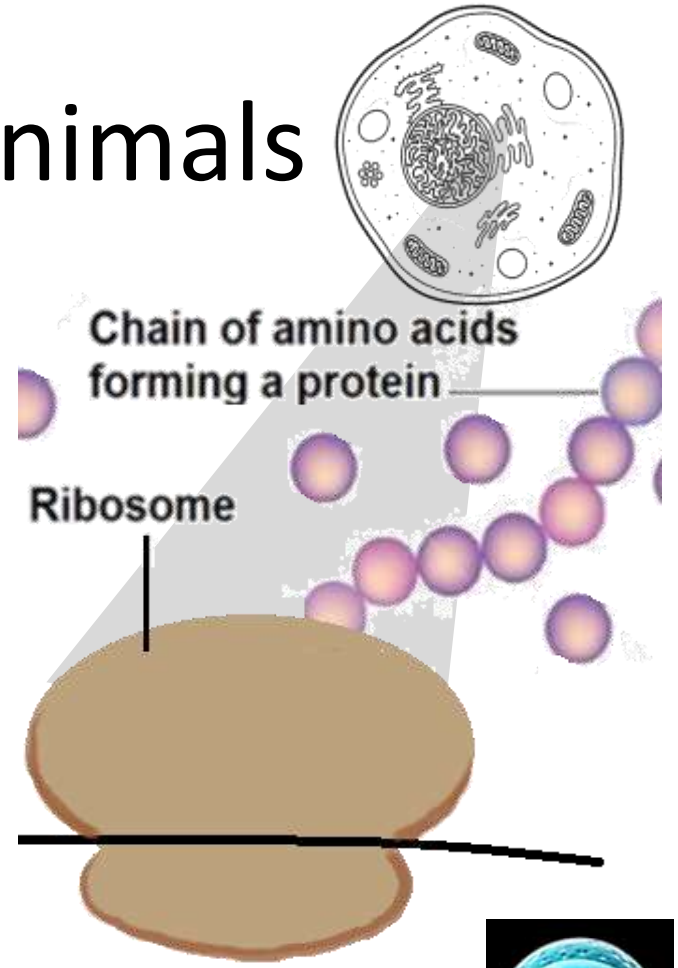
Reminders from Animals

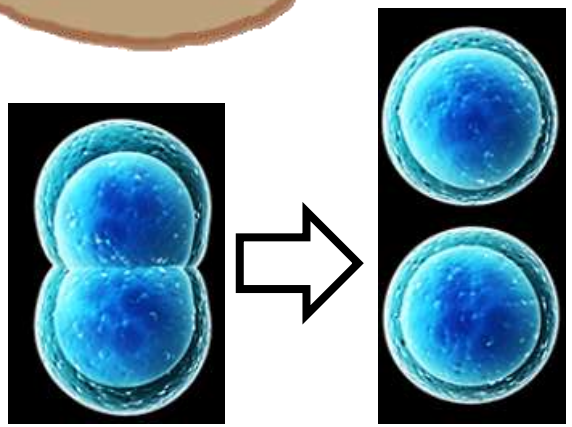
- **The food that animals consume provides either 1) energy or 2) matter.**
  - Cellular respiration is the process in which glucose and oxygen molecules are rearranged into CO_2 and H_2O to acquire chemical energy needed to recharge ATP.
  - Biosynthesis is the process in which organisms use consumed molecules to make macromolecules needed for cell function.



Reminders from Animals

- **Biosynthesis is the process in which organisms use consumed molecules to make the macromolecules needed for its cells.**
  - Cells first absorb individual molecules from the blood.
  - Structures inside the cell then assemble individual molecules into macromolecules like proteins.
- **As a cell assembles macromolecules, the cell grows bigger.**
  - The process of dividing one large cell into two smaller cells is called <u>mitosis</u>.

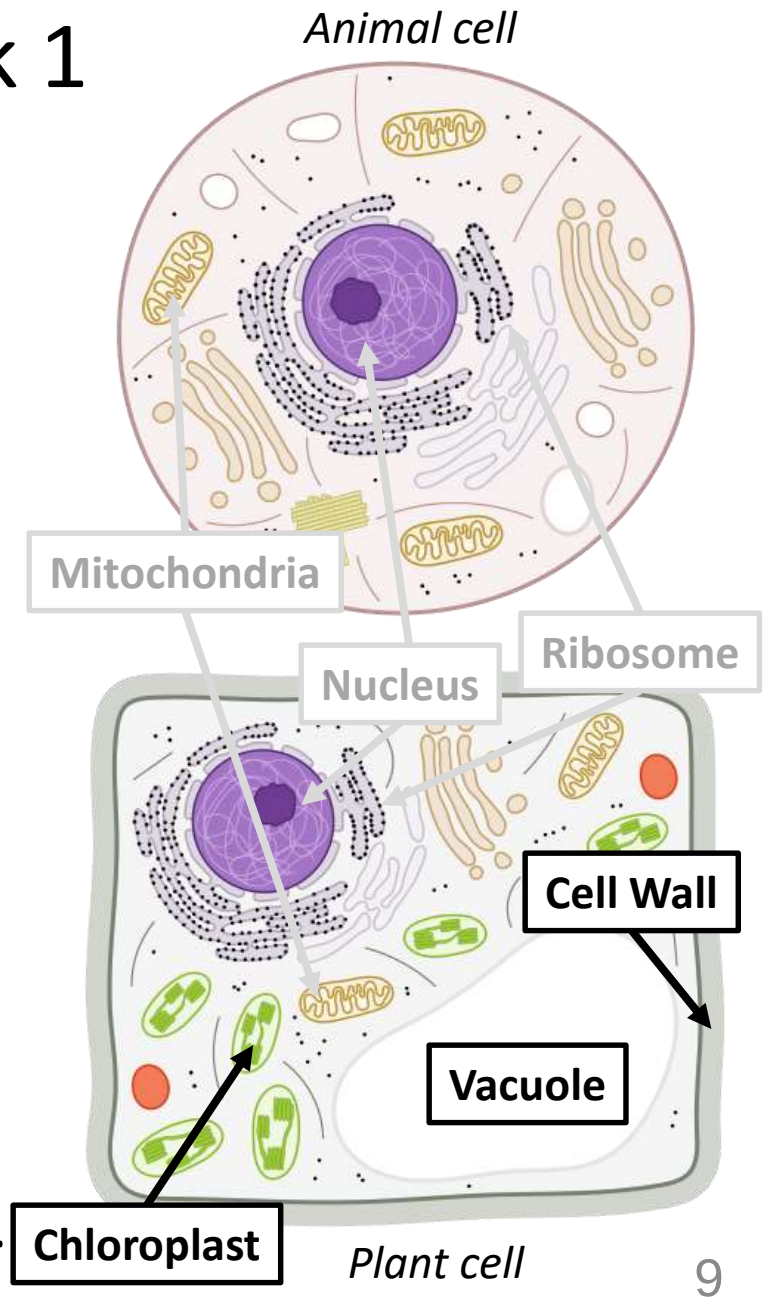




Source: www.123rf.com

Reminders from Plants, Wk 1

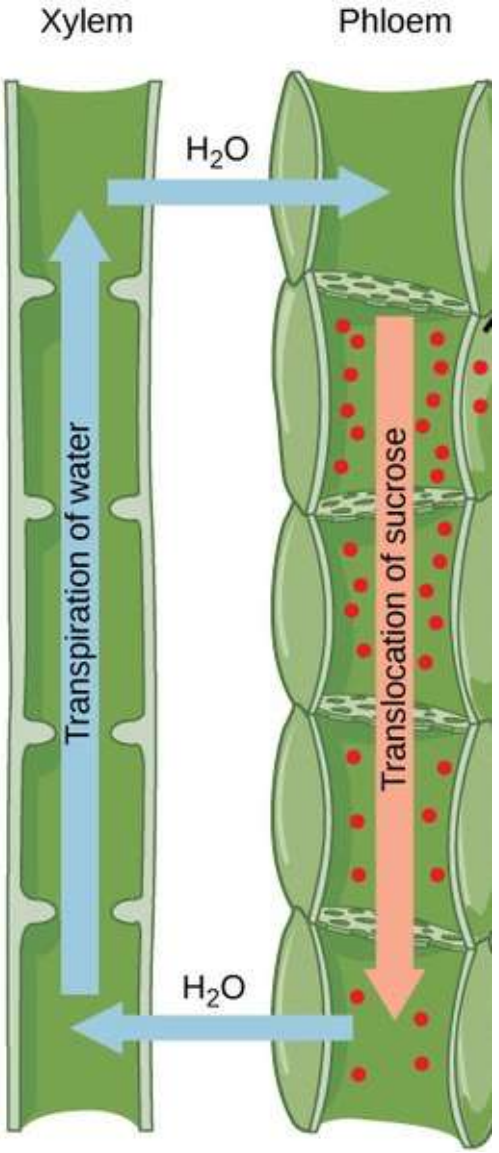
- **Most of the organelles found in animal cells are also found in plant cells.**
  - Plant cells also have a nucleus, mitochondria, and ribosomes, among other organelles.
- **Plant cells have three organelles that animal cells do not:**
  - **<u>Chloroplasts</u>:** where glucose is produced during photosynthesis.
  - **<u>Cell Wall</u>**: a rigid shell made from cellulose.
  - **<u>Vacuole</u>**: a storage organelle for waste products and other molecules.

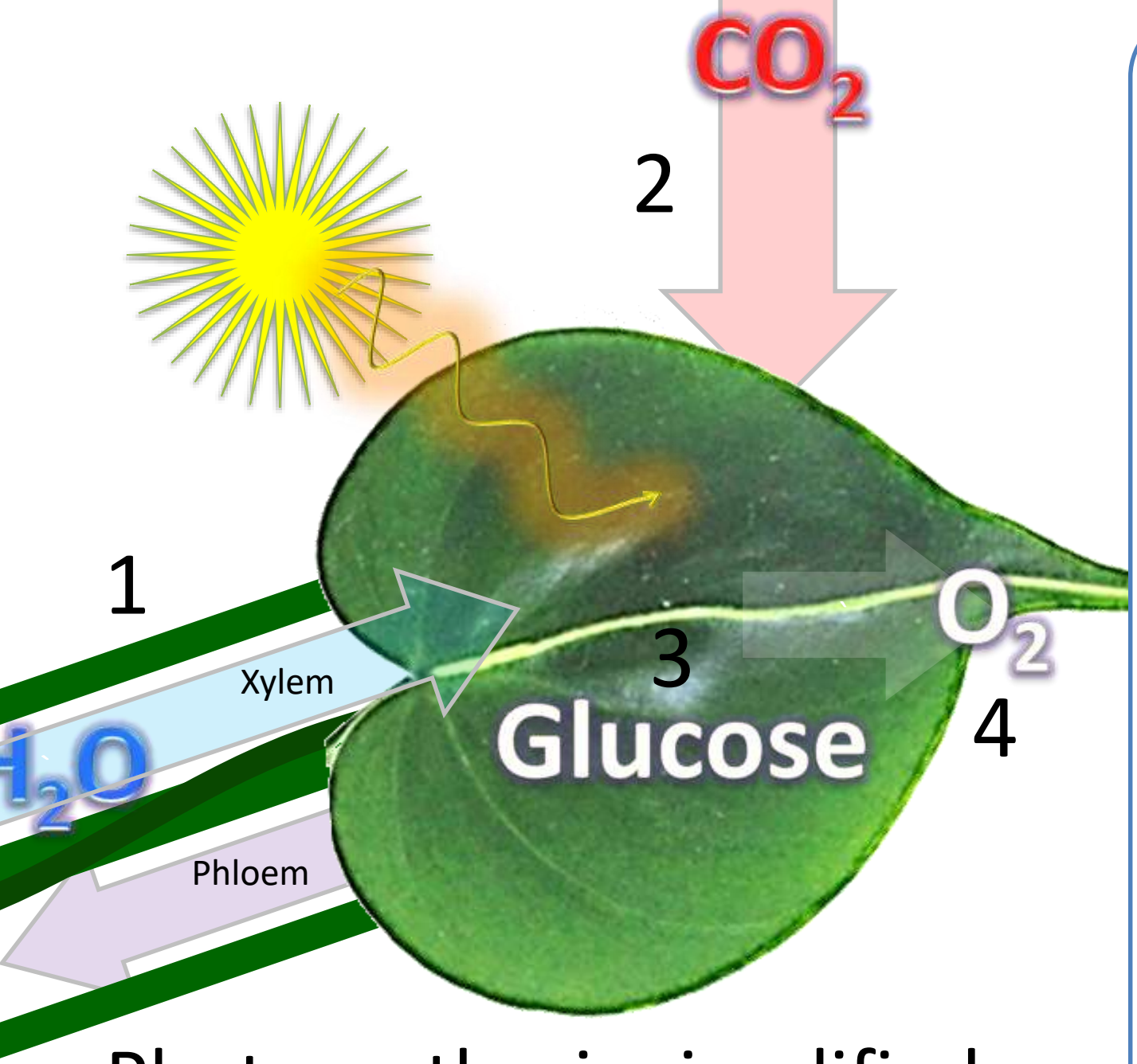


Reminders from Plants, Week 1

- **Plant cells are organized like animal cells.**
  - A group of plant cells form tissues.
  - Plant tissues form organs (roots, stems, leaves).
  - Plant organs form systems.

– **Plant tissues include xylem & phloem.**
  - Xylem are hollow tubes through which water and minerals move *up* through the plant as water is evaporated from pores in the leaves.
  - Phloem are tubes through which sugars move *down* throughout the plant via gravity.
  - Xylem & phloem in roots, stems, and leaves form a vasculature system (like the *circulatory system* in animals).





Photosynthesis simplified...

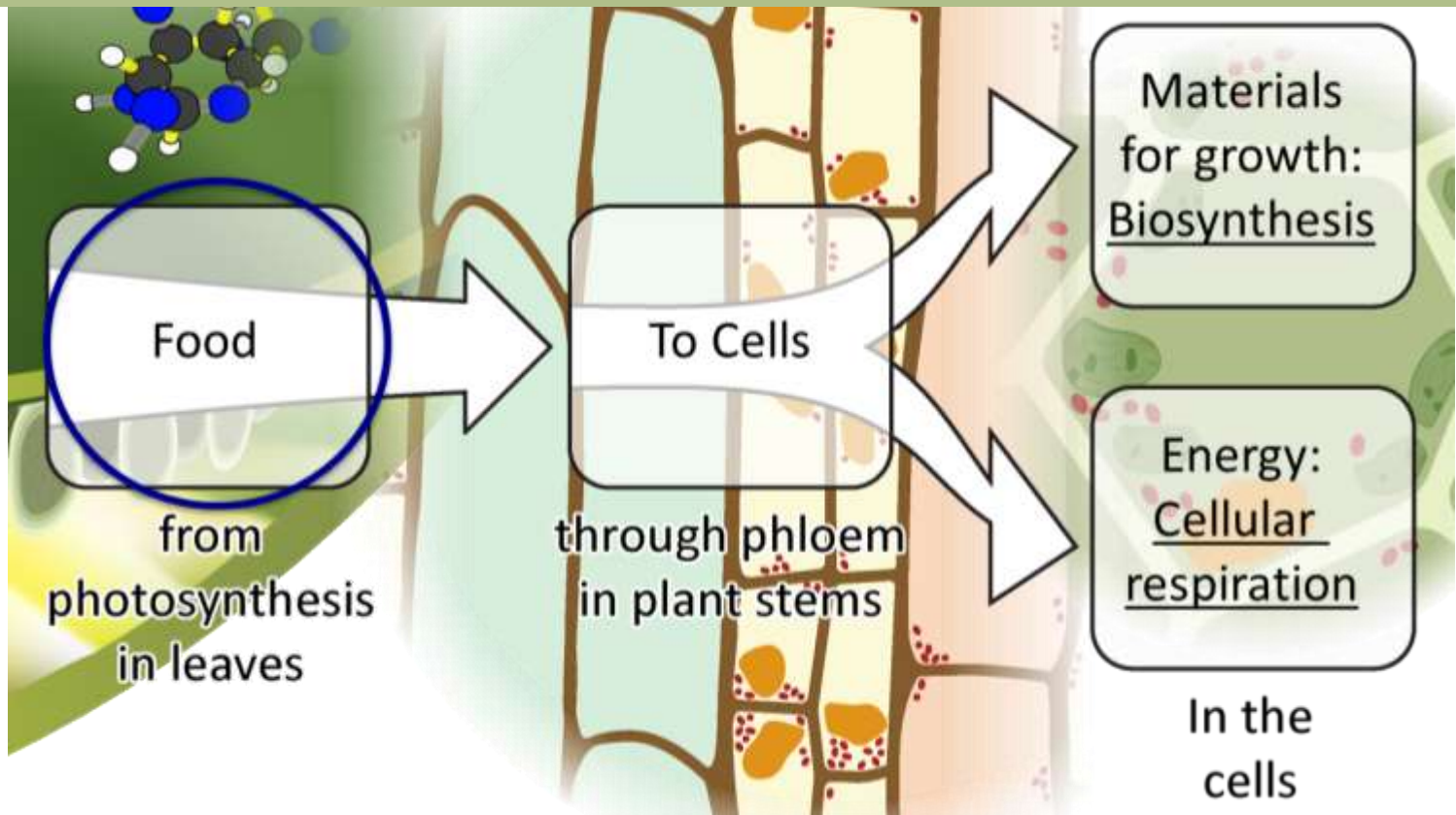
1. Evaporation pulls water up the xylem tubes into the leaves of the plant.

2. CO_2 is absorbed through pores in the leaves.

3. CO_2 and H_2O are rearranged to form glucose ($C_6H_{12}O_6$) and oxygen (O_2) using light energy.

4. O_2 is released. Glucose is used for cell resp. or biosynthesis.

- **Plants use some glucose produced during photosynthesis to recharge ATP during cellular respiration.**
  - This can occur within that cell or glucose can travel to other cells.
- **Glucose can be used in multiple forms of biosynthesis.**
  - Glucose can be assembled into long chains to form cellulose.
  - Atoms in glucose can be rearranged with minerals from the soil to form amino acids, fatty acids, etc.

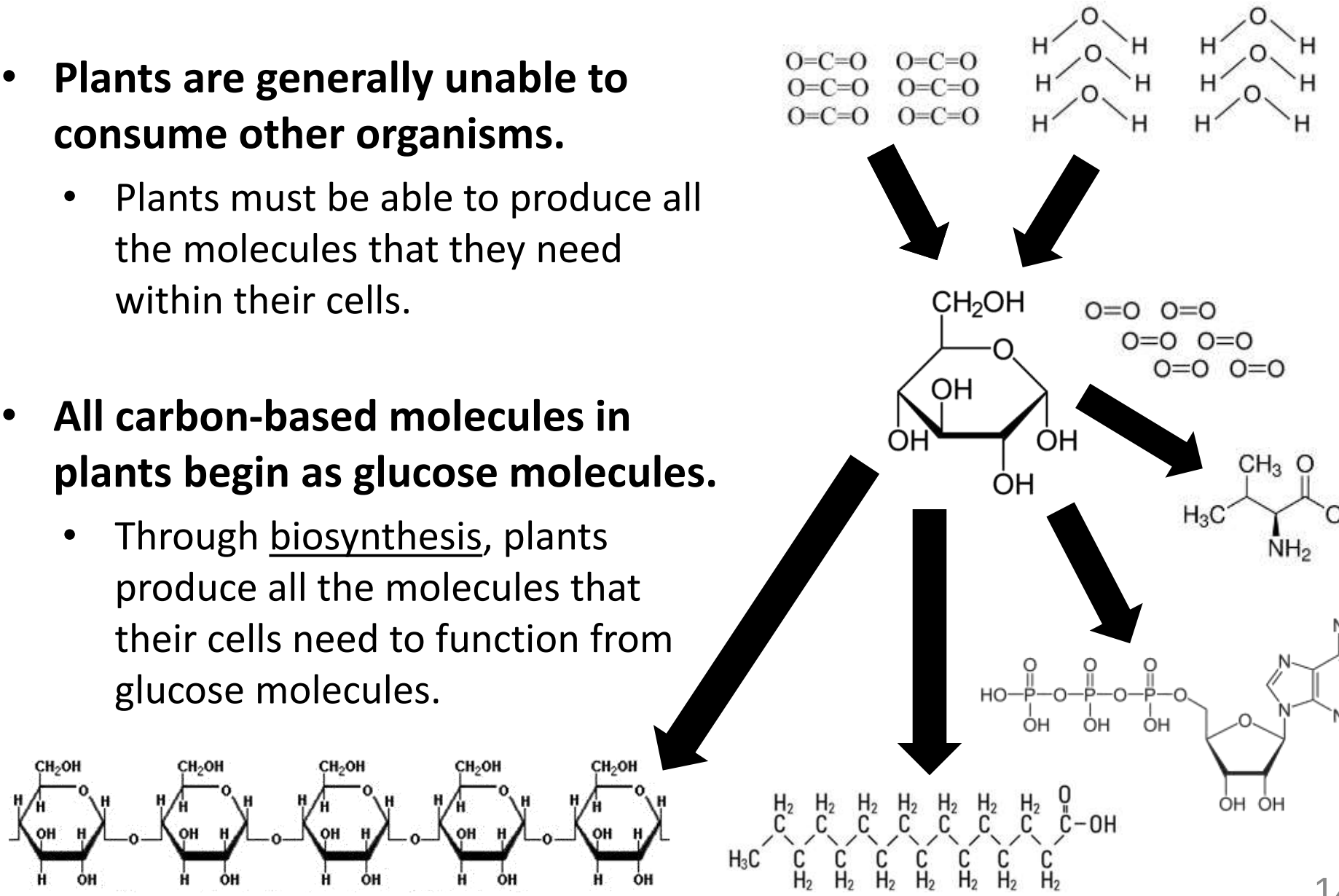




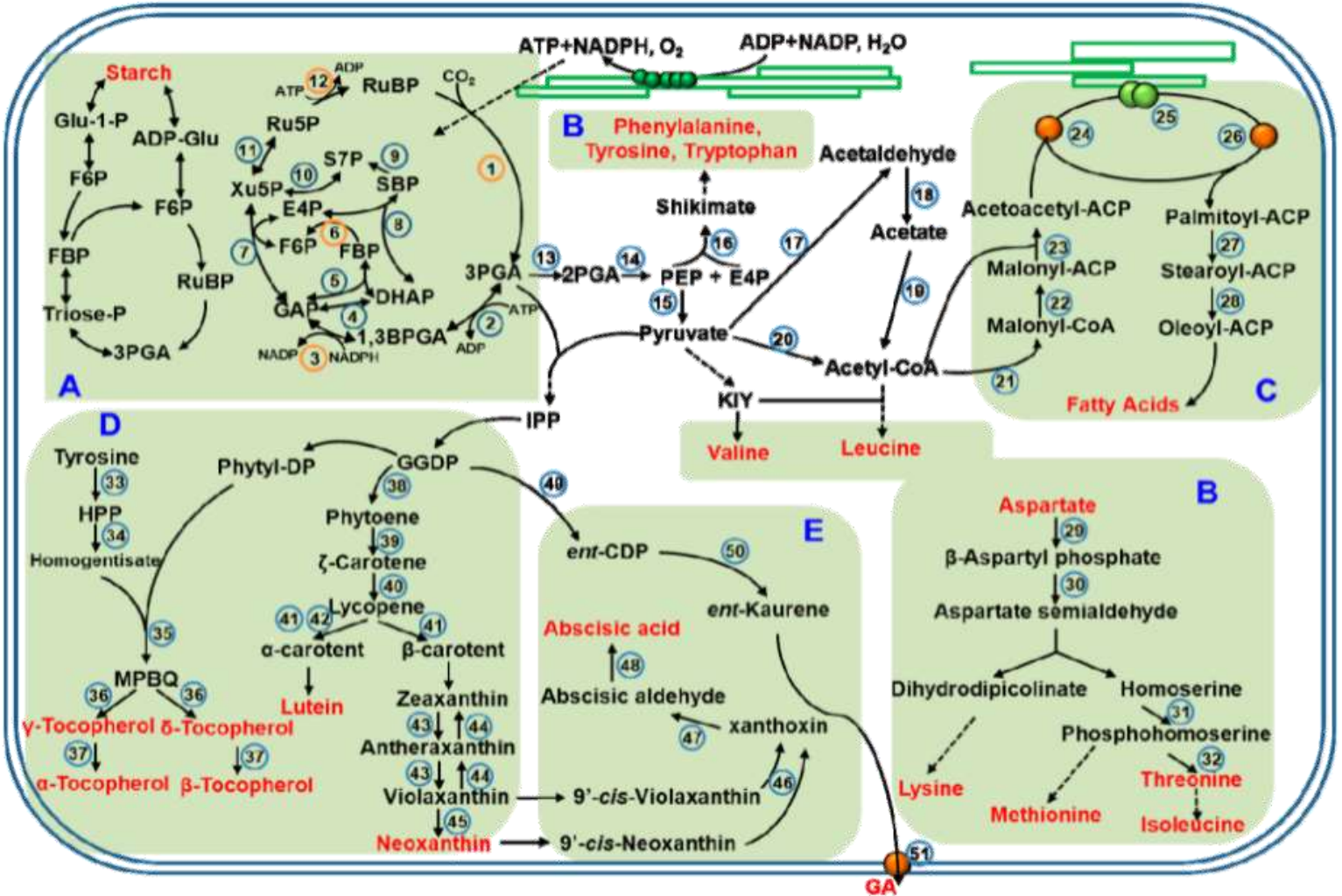
BIOSYNTHESIS & ENZYMES

It starts with glucose…

- **Plants are generally unable to consume other organisms.**
  - Plants must be able to produce all the molecules that they need within their cells.
- **All carbon-based molecules in plants begin as glucose molecules.**
  - Through biosynthesis, plants produce all the molecules that their cells need to function from glucose molecules.



- **Plant biosynthesis begins in the chloroplasts.**
  - Enzymes in the chloroplast can assemble glucose molecules into starch and cellulose macromolecules.
  - Chloroplast enzymes can also rearrange atoms in glucose and soil minerals to make fatty acids and amino acids.



Source: Chen, *et al.*, 2018

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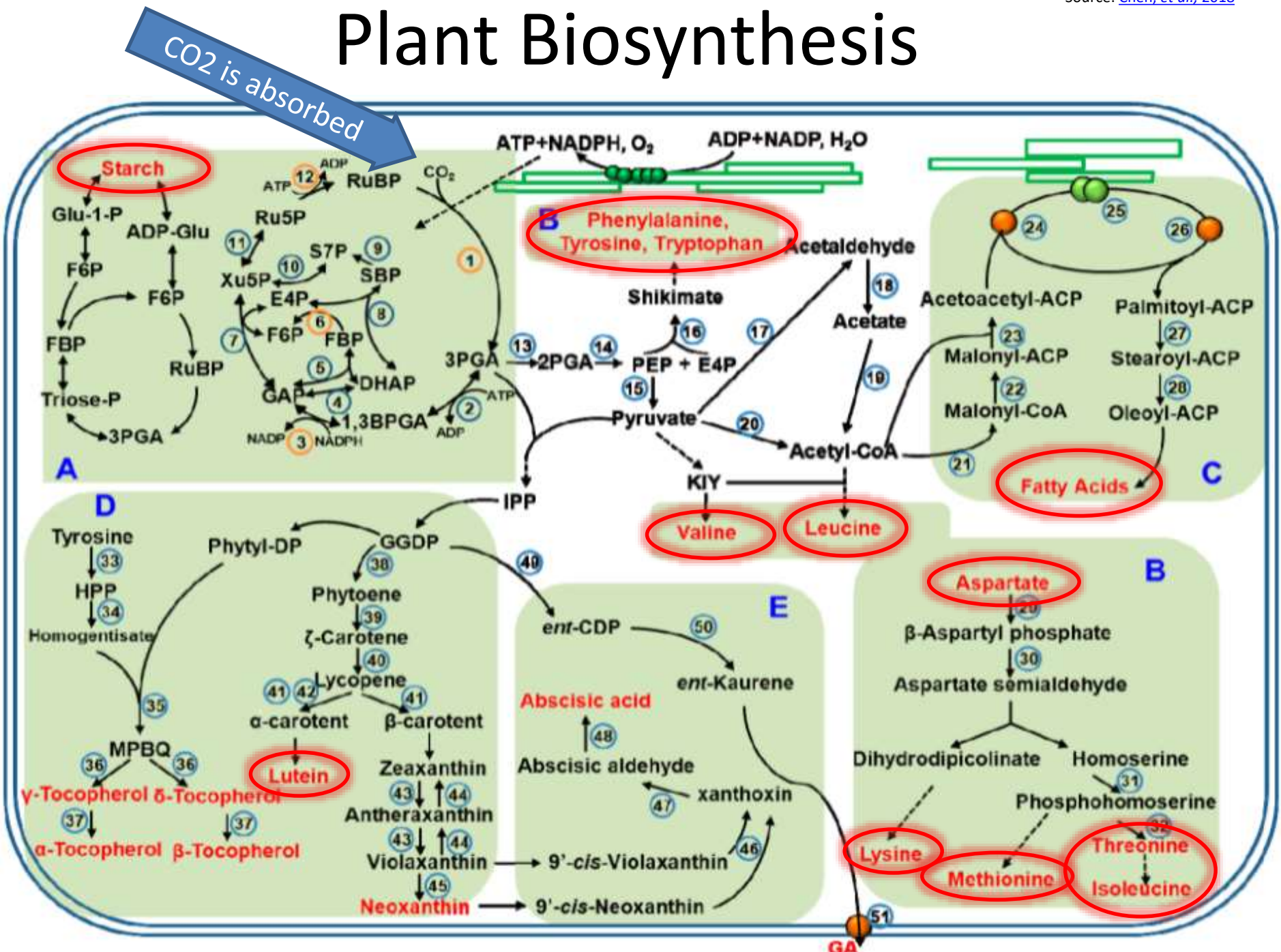
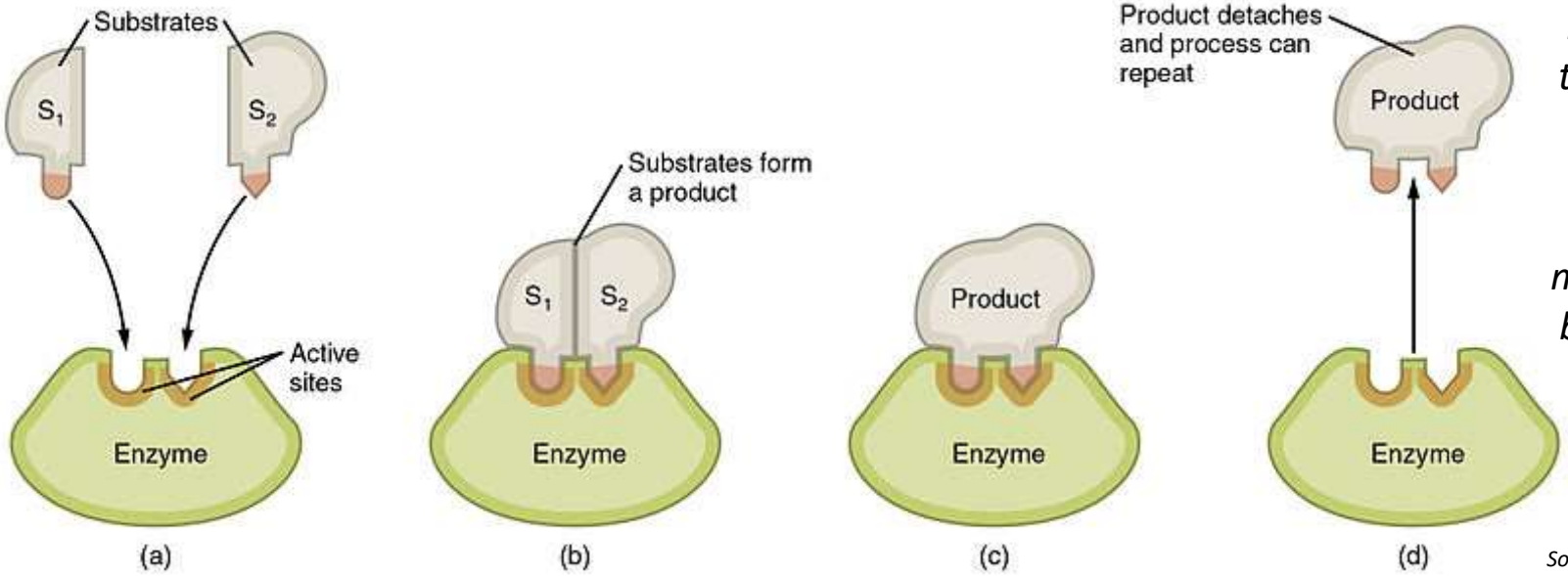
Plant Biosynthesis



Enzymes

- **All cells, including plant cells, depend on enzymes to rearrange atoms in molecules to form new molecules.**
  - Enzymes are specialized proteins that enable molecular reactions to occur more quickly and easily.
  - Enzymes reduce the amount of energy (ATP) and time needed for a reaction to occur within an organism.
  - Enzymes enable new molecules to be formed but are not part of the molecules that are produced during a reaction.

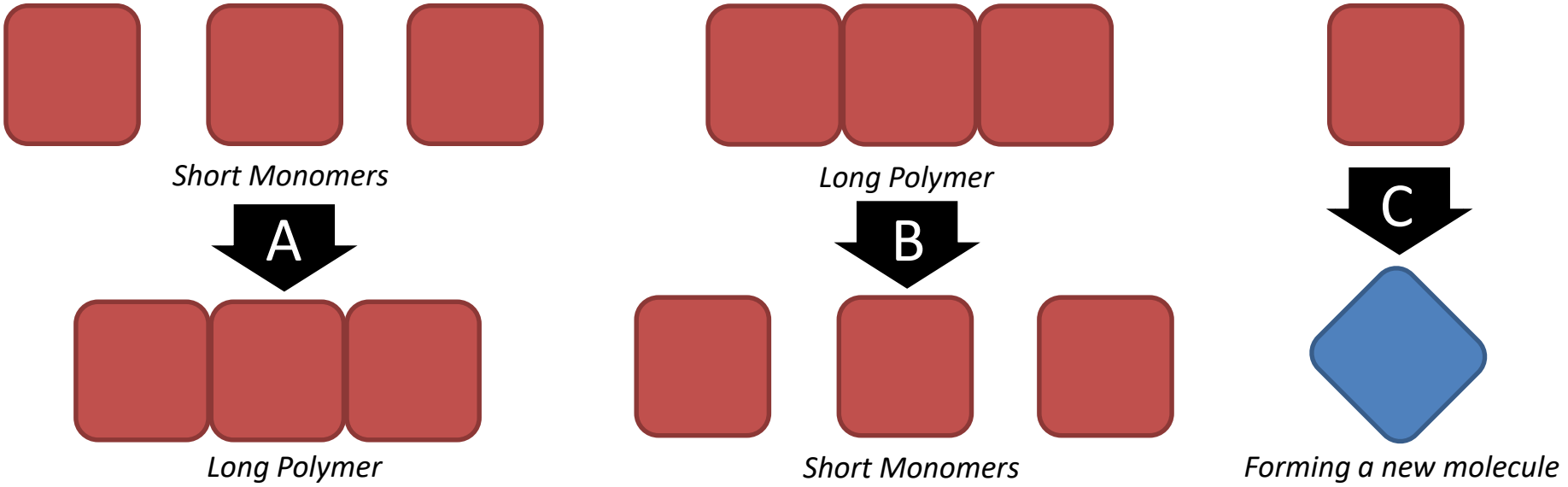


In this image, two molecules are joined together to form a new macromolecule by an enzyme.

Source: Wikimedia Commons

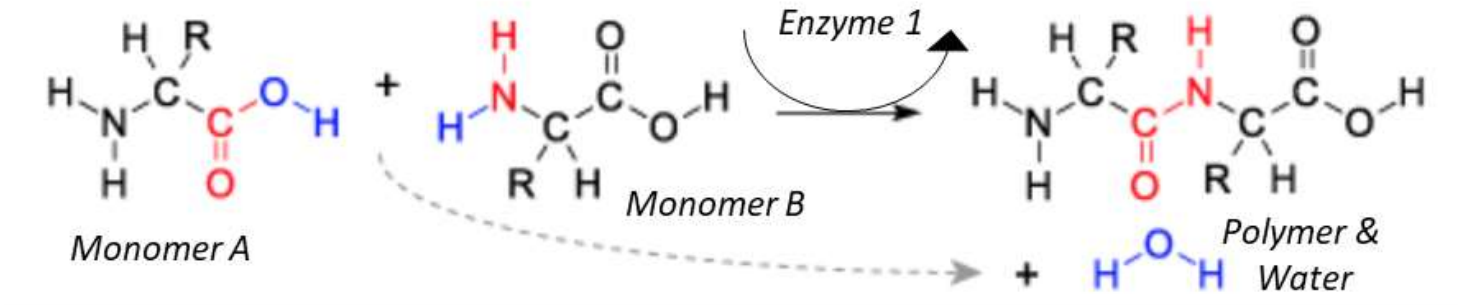
Monomers & Polymers

- **Enzymes can create larger, smaller, or different molecules depending on their function.**
  - A) Some enzymes assemble individual molecules (monomers) into large repeating chains (called *macromolecules* or polymers).
  - B) Some enzymes disassemble long polymers into individual monomers.
  - C) Some enzymes rearrange atoms to form entirely new molecules.

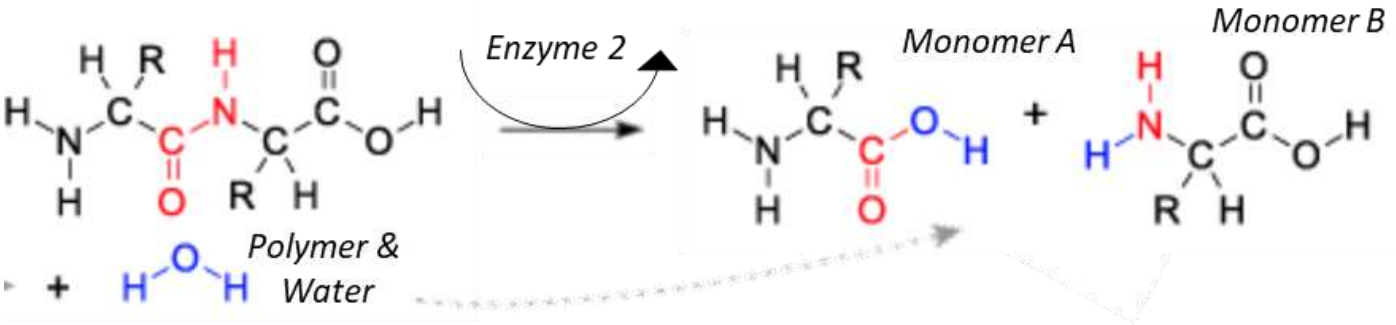


Monomers & Polymers

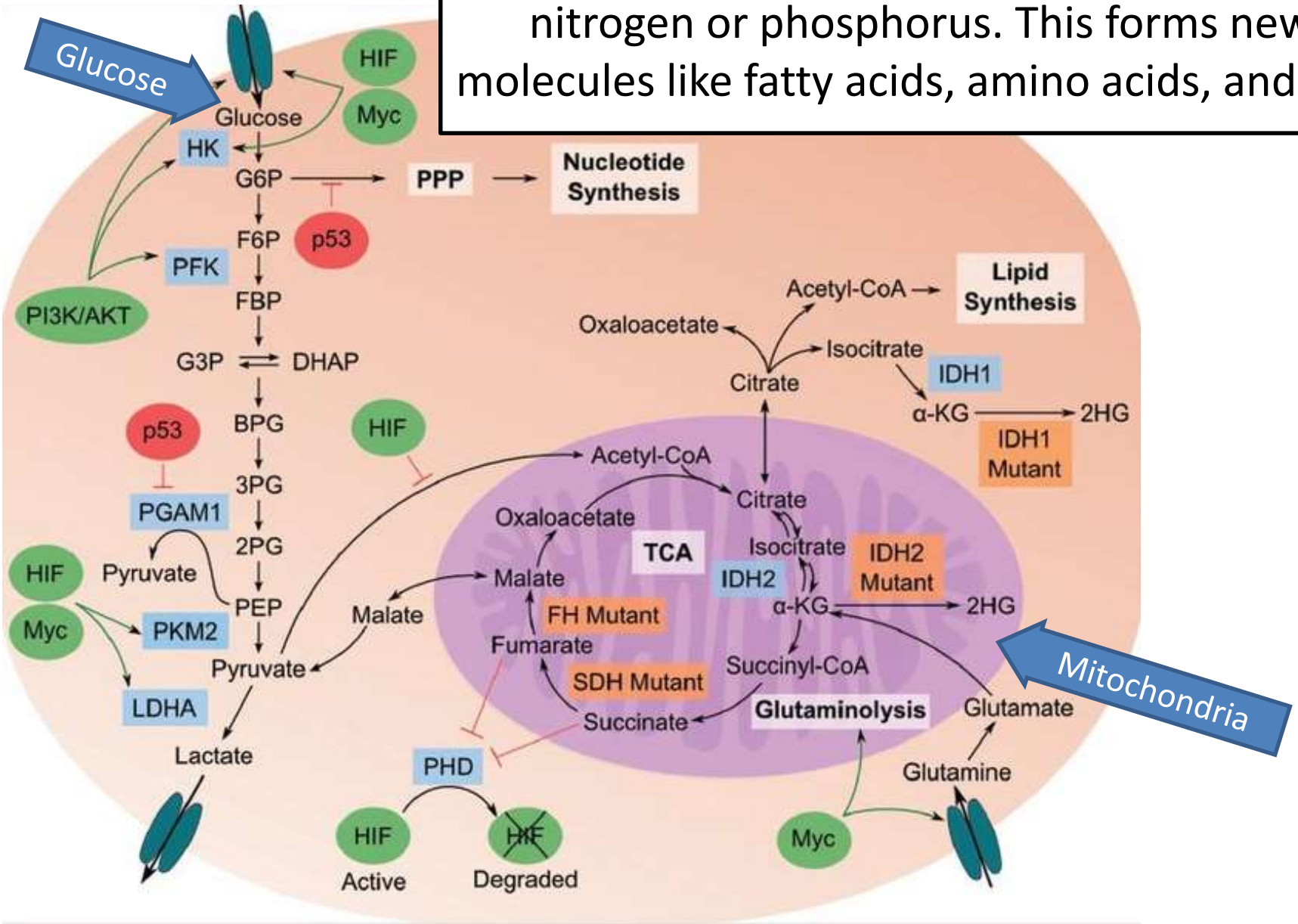
- **Enzymes can combine short monomers to form long polymers by removing oxygen and hydrogen atoms.**
  - These atoms combine to form a separate water molecule.



- **Similarly, enzymes can break apart long polymers by "inserting" a water molecule between each monomer**.
  - This causes the bond between the monomers to break apart.



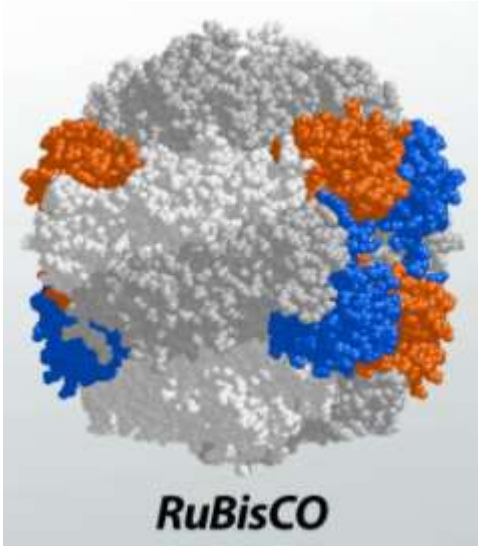
Some enzymes in eukaryotic cells rearrange the atoms in glucose with minerals like nitrogen or phosphorus. This forms new molecules like fatty acids, amino acids, and ATP.



Source: https://commons.wikimedia.org/wiki/File:TumorMetabolome.jpg?scrlybrkr=8adfb6f9

Source: Study.com

Enzymes



- **Enzymes are critical for the function of plant cells.**
  - For example, *Rubisco* is an enzyme in chloroplasts that is needed for photosynthesis.
  - *Rubisco* adds carbon atoms from CO_2 to the atoms from H_2O to assemble a glucose molecule.
  - Another enzyme, called *starch synthase*, can then assemble glucose monomers into starch polymers.
- **Some plant enzymes can *disassemble* long polymers into short monomers.**
  - For example, the starch in plant seeds provides a source of chemical energy as a seedling grows.
  - An enzyme called *amylase* breaks down starch polymers into glucose monomers.
  - This enables the seedling's mitochondria to use chemical energy from glucose to recharge ATP.

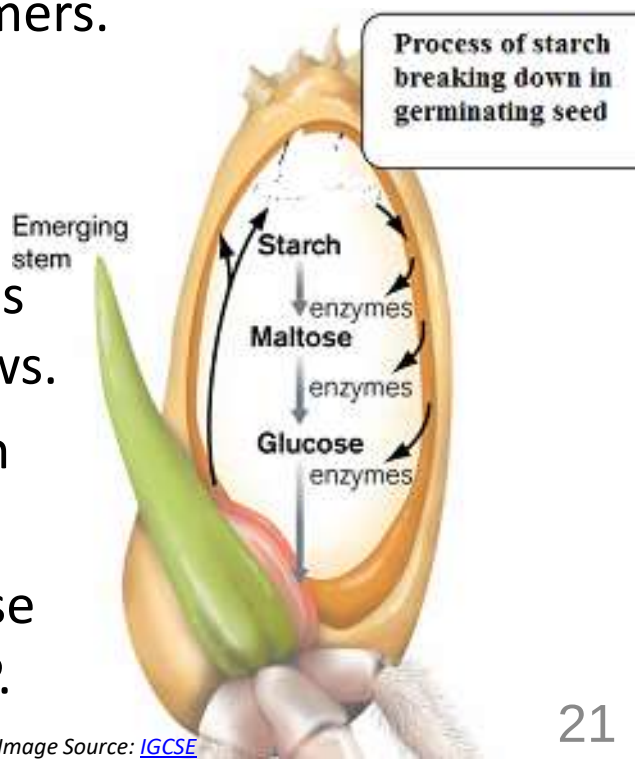
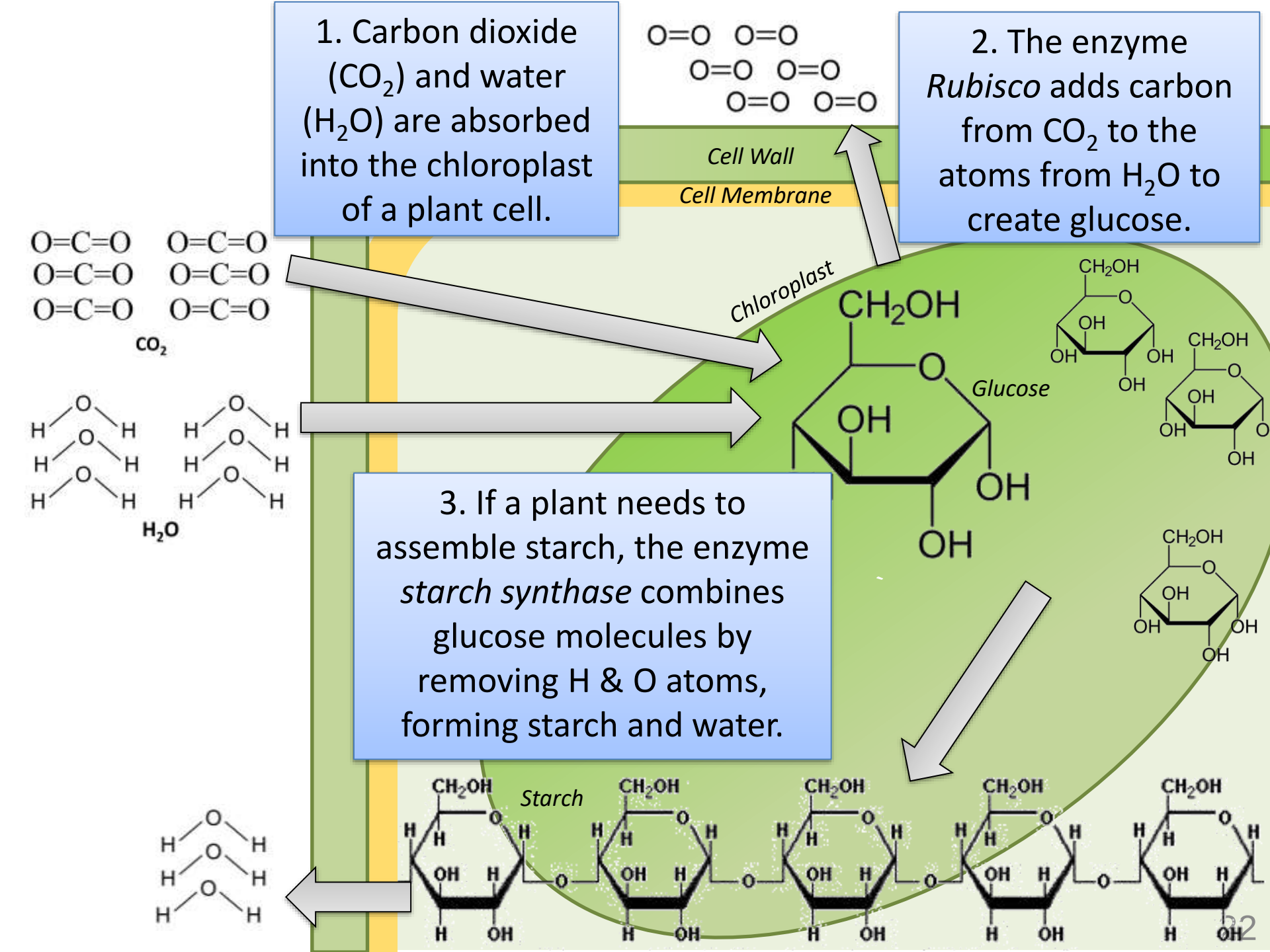
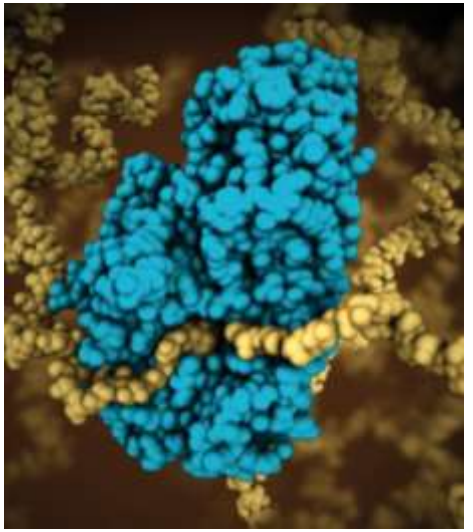


Image Source: IGCSE

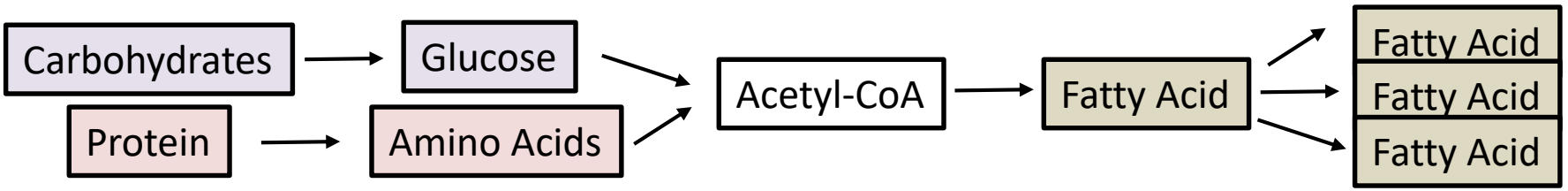

1. Carbon dioxide (CO_2) and water (H_2O) are absorbed into the chloroplast of a plant cell.
2. The enzyme *Rubisco* adds carbon from CO_2 to the atoms from H_2O to create glucose.
3. If a plant needs to assemble starch, the enzyme *starch synthase* combines glucose molecules by removing H & O atoms, forming starch and water.
Cell Wall
Cell Membrane
Chloroplast
CO_2
H_2O
Glucose
Starch

Animal Enzymes



The amylase enzyme, found in plants & animals, breaks starch polymers into glucose monomers.

- **Like plant cells, animal cells also depend on enzymes to function.**
  - For example, enzymes in the digestive tracts of animals break down carbohydrate polymers into individual glucose monomers.
  - Digestive enzymes include *amylase* in animal saliva, which breaks starch into separate sugar molecules.
- **Animal cells can also have enzymes that assemble monomers into polymers.**
  - For example, *fatty acid synthase* consists of multiple enzymes that assemble fat polymers using molecules from consumed food.
  - *Fatty acid synthase* enables animal cells to convert carbohydrates and protein into fat, allowing the cell to store energy for later use.



Plant & Animal Interactions

- **Cellular reactions affect how species interact with each other.**
  - For example, when animals consume plants, enzymes in their digestive tracts disassemble the macromolecules (polymers) from plant cells into the individual monomers.
  - Animal cells then reassemble the monomers into polymers OR their cells rearrange the atoms in monomers to make other molecules needed by the cell OR their cells rearrange plant molecules and oxygen into CO_2 and H_2O during cellular respiration.

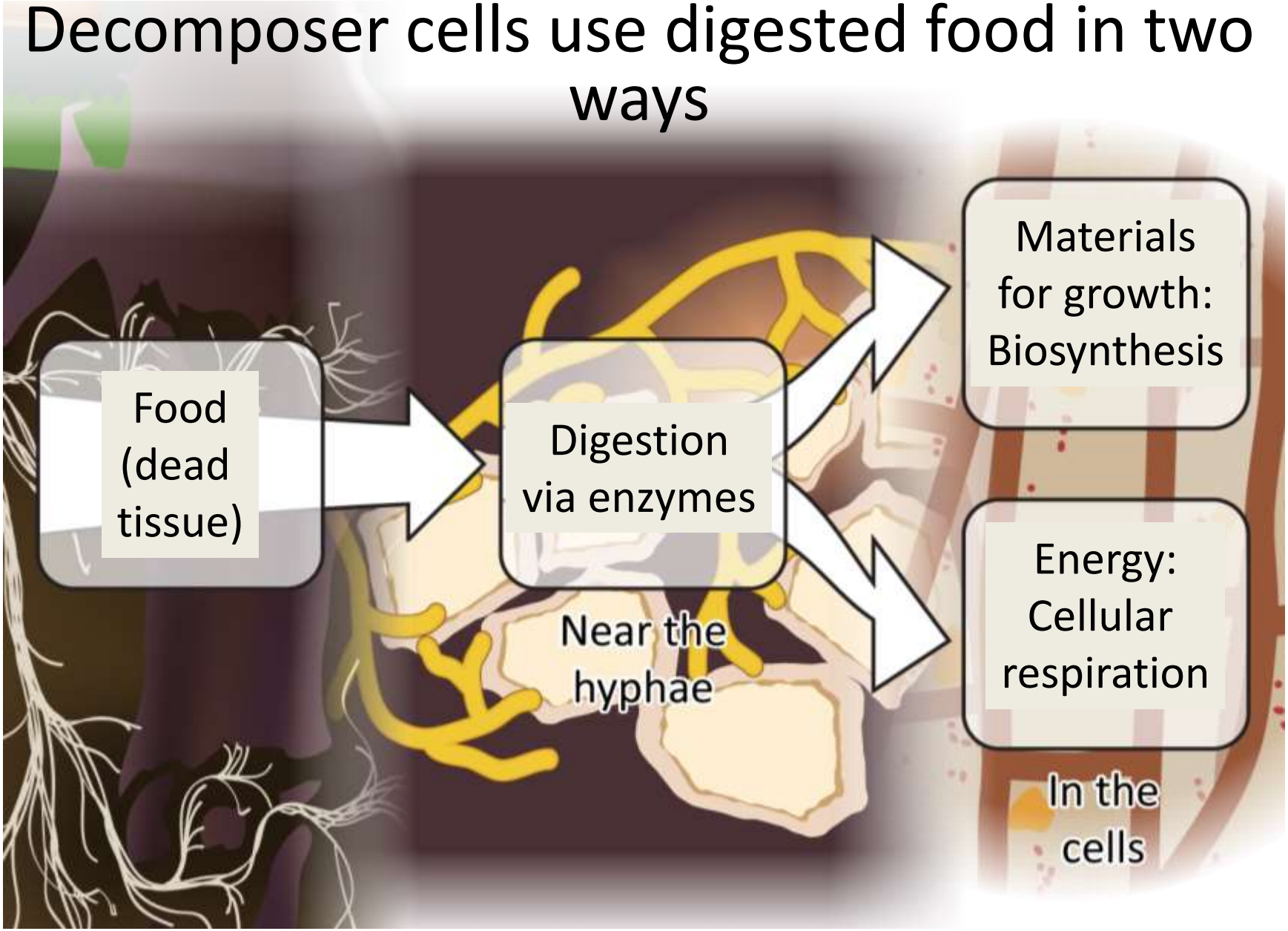
Source: Public Domain Pics

Decomposers

- **Decomposers (such as fungi like mushrooms as well as bacteria) can also use enzymes to break down the dead or dying tissues from organisms like plants and animals.**
  - These enzymes break down polymers into monomers.
  - Decomposers can then absorb and reassemble into the macromolecules needed by their cells OR use monomers during cellular respiration (especially glucose and fatty acids).
  - Decomposers eventually convert most carbon-based molecules with high-energy bonds back into CO_2 and H_2O.

Source: Pixfuel

Decomposer cells use digested food in two ways



Revising Our Claims

- **Revisit this week's driving question: What happens inside plant cells?**
- We observed that peanuts have high concentrations of fat and protein.
- How can a plant acquire fat and protein without consuming other organisms?
- Revise your explanation using the following terms: *enzymes, monomers, polymers.*

Looking Ahead: Part 3 Investigation

- In Part 3, you will be investigating what kinds of pigments are found in plant cells and determining how these pigments were formed.