Metabolism, Energy & ATP

- Define & describe a metabolic pathway.
- Recognise different types of metabolic pathways.
- Recognise some of the enzymes used in metabolic pathways.

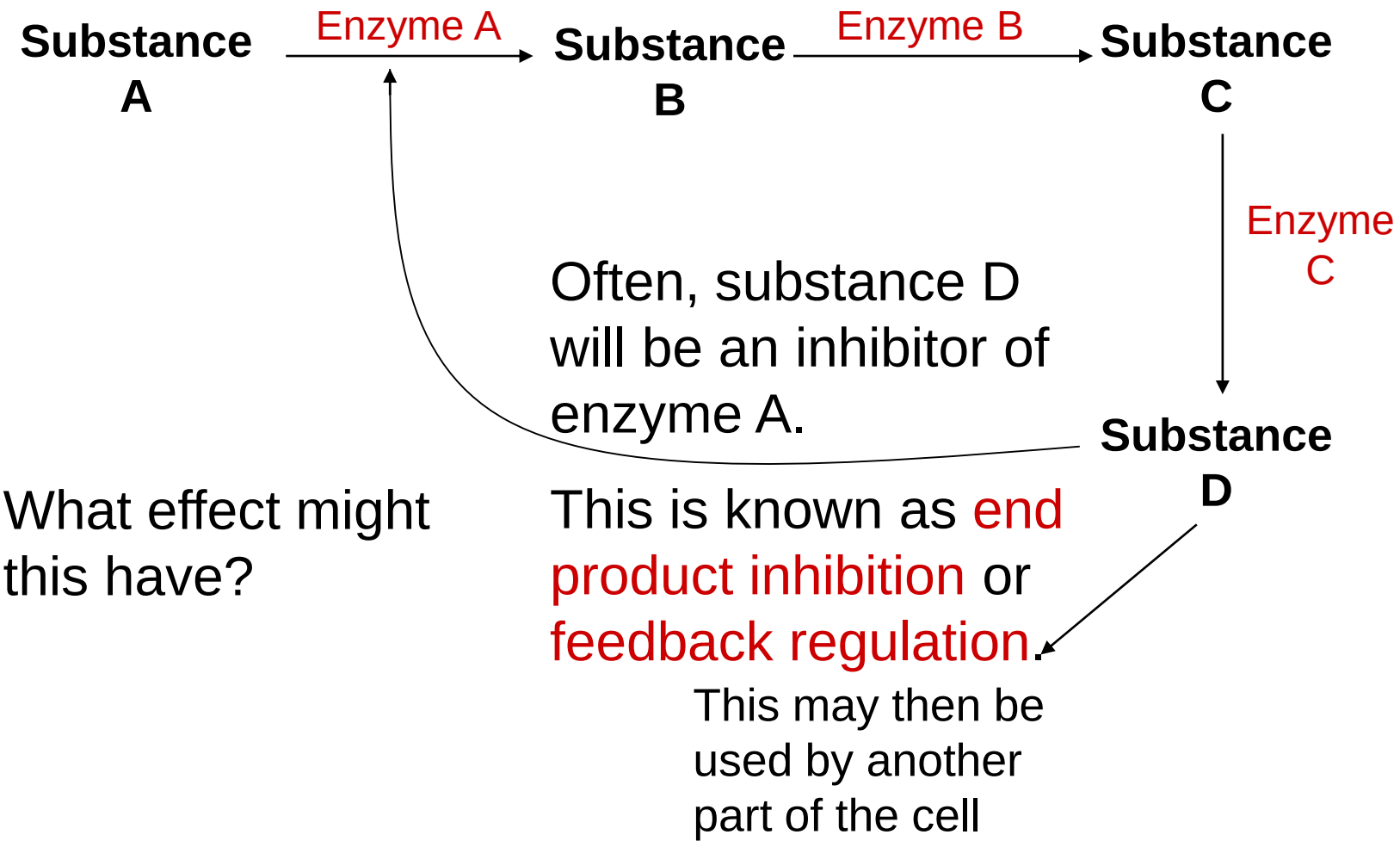
What is a Metabolic Pathway?

- Any ideas?

- Metabolism = All the chemical reactions that take place within a living organism (usually controlled by enzymes).

- A metabolic pathway is a sequence of enzyme controlled reactions.
  - The product of one reaction acts as the substrate for the next.

Example of a Metabolic Pathway.



Often, substance D will be an inhibitor of enzyme A.

What effect might this have?

This is known as end product inhibition or feedback regulation.

This may then be used by another part of the cell

Types of Metabolic Pathways

- Metabolism is a general term for all reactions in the body.
- There are 2 types of metabolic reactions:
  - Anabolism (or anabolic reactions).
    - The build up of larger, more complex molecules from smaller, simple ones.
    - These require energy.
  - Catabolism (or catabolic reactions).
    - The breakdown of complex molecules into simple ones.
    - These release energy.

Anabolic or Catabolic?

- Starch into glucose?
  - Catabolic, hydrolysis reactions.
- Amino acids into peptides?
  - Anabolic, condensation reactions.
- Nucleotides into RNA?
  - Anabolic, condensation reactions.
- Triglycerides into fatty acids & glycerol?
  - Catabolic, hydrolysis reactions.

What types of enzymes are used in metabolism?

- Using the example of respiration:
  - $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$
  - This does not happen all in one go but in a long series of small steps.
    - Each step may break/make just one bond or add/remove an electron.
    - Each step will need its own enzyme to control it.
    - Each enzyme is specific to a particular reaction with a particular substrate.
    - There are many enzymes involved in respiration.
      - Each enzyme has its own name.

What types of enzymes are used in metabolism?

- We can group enzymes together according to the types of reactions they catalyse.
  - Hydrolase enzymes control hydrolysis reactions.
  - Oxidoreductase enzymes control redox reactions.
  - Transferase enzymes move whole chemical groups (eg. methyl, amino, carboxyl).
  - Isomerase enzymes change the shape of a molecule (creating an isomer)

Mini Summary Test

1. Define the term “metabolic pathway”. (2)
2. Name and describe the 2 types of metabolic reaction. (4)
3. Describe the action of the following types of enzyme: (2)
   a) Oxidoreductase
   b) Hydrolase

Total = 8 marks.

Answers

1. A sequence of reactions / occurs in small steps ;
   Controlled by enzymes. (2)
2. Anabolism – build up of large molecules.
   Catabolism – breakdown of large molecules. (4)
3. a) Oxidoreductases control redox reactions/transfer electrons. (1)
   b) Hydrolases control hydrolysis reactions. (1)

Energy & ATP

- What is energy?
- How do living organisms store energy for use?

What is Energy?

- Any ideas?
- Energy is the ability to do work.
- There are two states of energy:
  - Kinetic
  - Potential

Kinetic Energy

- The energy of motion.

- Moving objects perform work by making other objects move:

Potential Energy

- Stored energy.

- An object that is not moving may still have the potential to do work – it has potential energy.

Energy's many forms

- There are many different forms of energy.
- Can you name some of them:

Light

Sound

Heat

Atomic

Electrical

Kinetic

Magnetic potential

Gravitational potential

Chemical potential

Elastic potential

Energy…

- Can be changed from one form to another.
  - Eg. From kinetic to electrical, from chemical to heat.
- Cannot be created or destroyed.
- Is measured in Joules.

Without an input of energy…

- Rooms become untidy.
- Uninhabited buildings become derelict.
- Natural processes tend to break down into randomness & disorder.

What has this got to do with Biology?

- Living organisms are highly ordered systems.

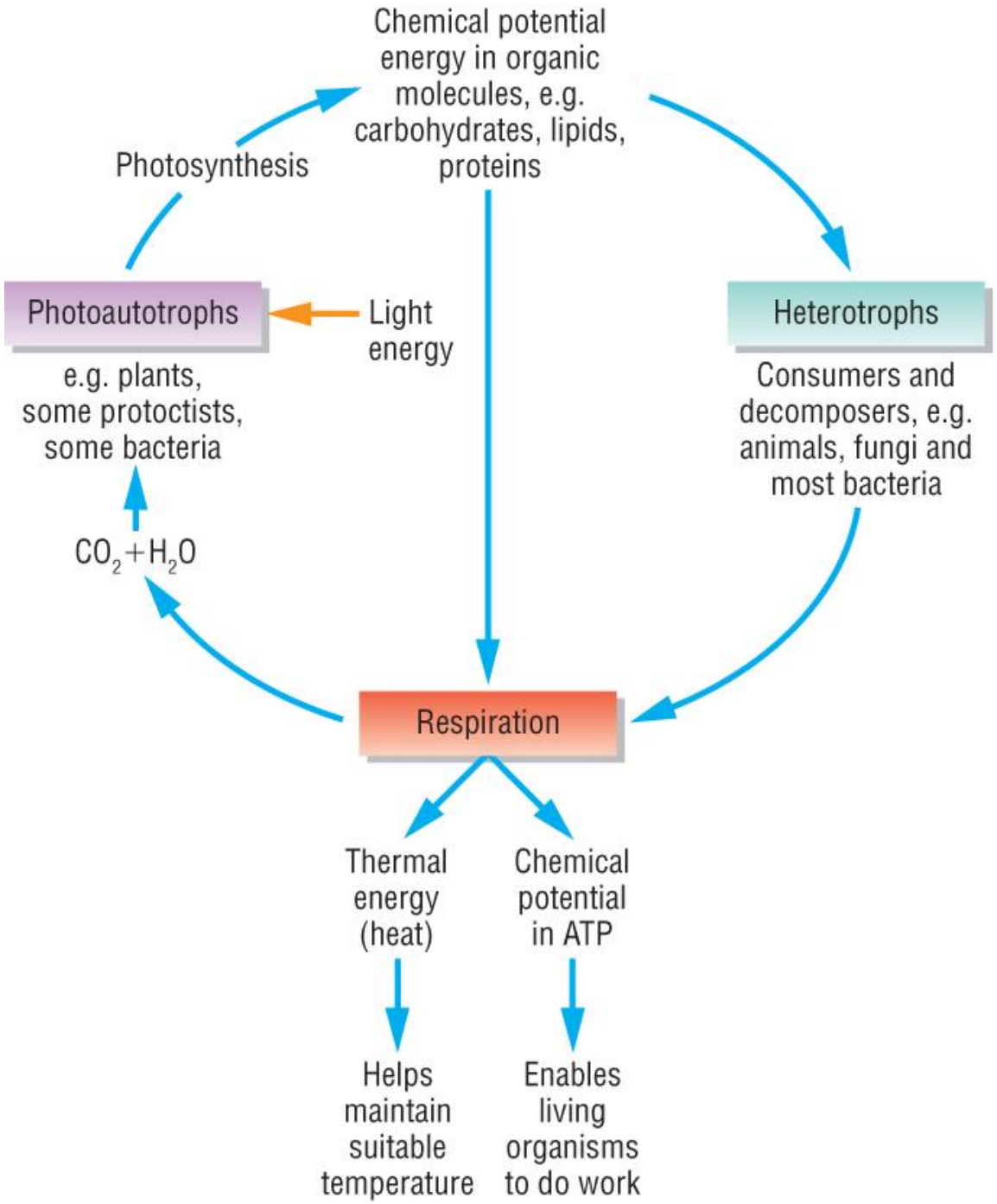
- They need a constant input of energy to stop them from becoming disordered (which would lead to death).

What, specifically, do living things need energy for?

- A year 7 answer would be “for growth & repair”.

- A year 13 answer would be:
  - Metabolism (particularly anabolism).
  - Movement (within an organism & of the organism).
  - Active transport.
  - Maintenance, repair & cell division.
  - Homeostasis (particularly of body temperature).
  - Secretion of chemicals (Eg. Hormones).

Where does our energy come from?

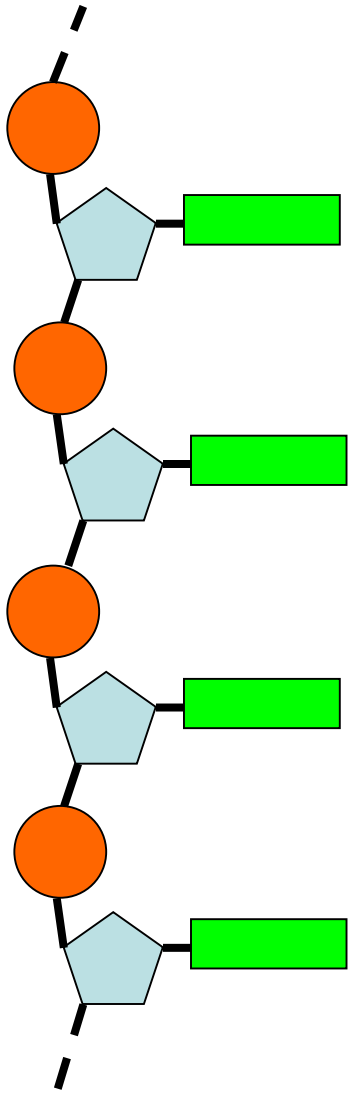


ATP & other TLAs

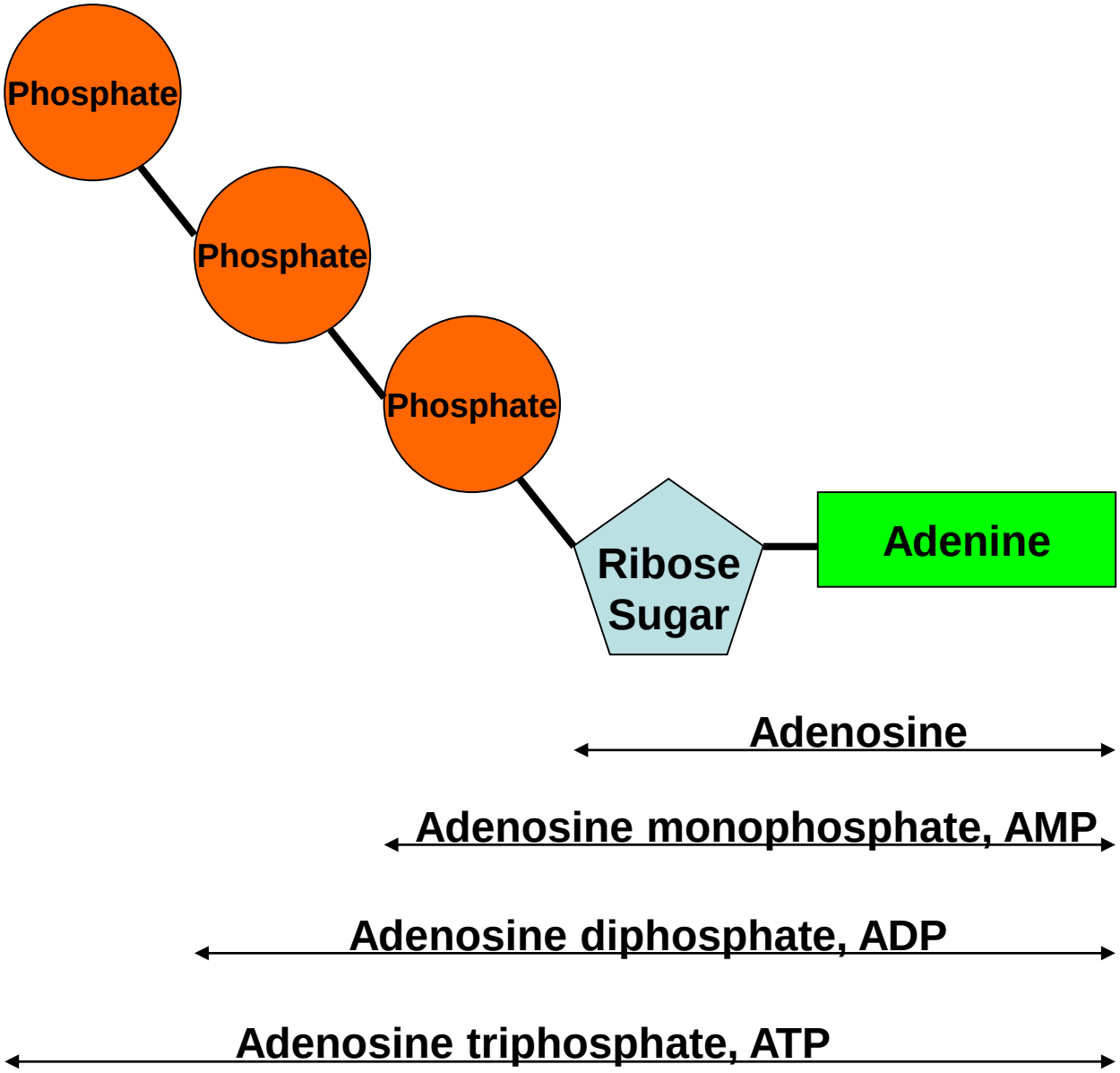
- Adenosine Triphosphate (ATP) is the main energy currency of living cells.
- ATP is a small, water soluble molecule.
  - It is therefore easily transported around the cell.
- ATP stores energy as chemical potential energy.
  - Think of it as a tiny loaded spring.

The Structure of ATP

- Think back to the work on nucleic acids.
- This is RNA with its sugar-phosphate backbone and nitrogenous bases.
- The sugar is ribose and the bases are Adenine, Uracil, Cytosine or Guanine.



The structure of ATP

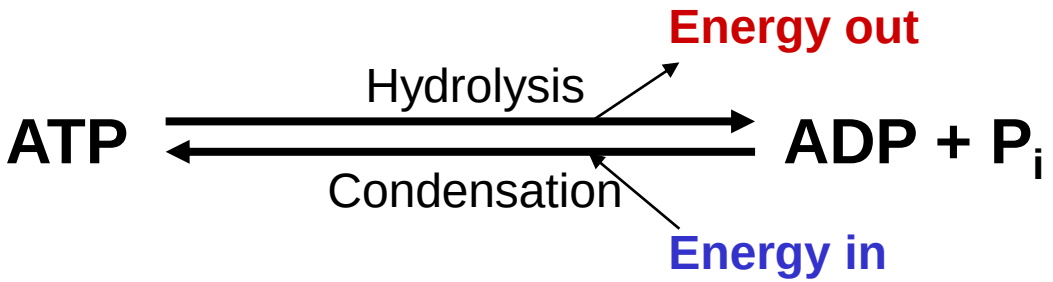


How does ATP store energy?

- Each phosphate group is very negatively charged.
  - So they are all straining to get away from each other.
  - The covalent bonds holding them together are easily broken.
  - When they break, P_i is released along with 30.6kJmol^{-1} of energy for each of the first two phosphates removed.
  - it is literally like a loaded spring waiting to be released.

Synthesis of ATP

- The conversion of ATP to ADP is reversible.
  - Energy from respiration can be used to combine ADP with P_i to re-from ATP.
    - This reaction is called phosphorylation and is an example of a condensation reaction.
    - It is catalysed by ATP synthase or ATPase.



The role of ATP

- The instability of ATP's phosphate bonds makes it a rubbish long term energy storage molecule.
  - Imagine a garage full of loaded mousetraps all set to snap closed at the slightest touch…
  - Fats and carbohydrates are better for this.
- ATP is the intermediate energy source.
  - So the cell does not need large quantities of ATP.
  - It maintains only a few seconds supply.
  - ATP is rapidly reformed so a little goes a long way.

Exam Question:

- Describe the structure of ATP.

.....

.....

.....

.....

.....

[Total: 4 marks]

Mark Scheme:

accept labelled sketch diagram for marking points below

- nitrogenous base / purine;
  adenine;
  pentose / 5 carbon, sugar;
  ribose;
  three, phosphate groups / Pi; **R** phosphate molecule
  phosphorylated nucleotide;
- **A** adenosine as an alternative to adenine **plus** ribose
- **4 max**

Summary

- Draw a review poster to summarise the work on Metabolism, Energy & ATP.
  - Use diagrams, mind maps, flowcharts or any other method you like.