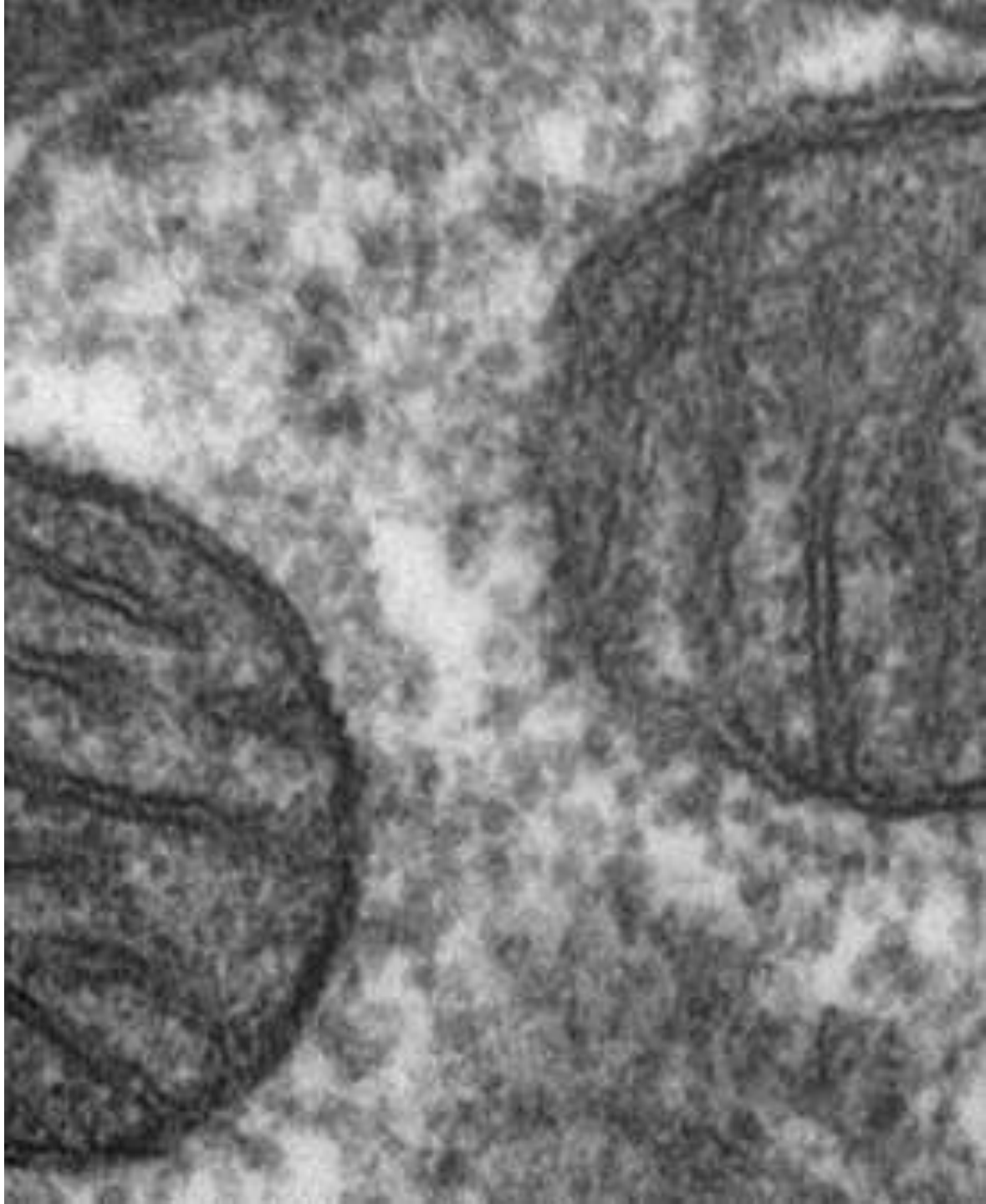
DP Biology – C1.2

Cell respiration

- What do hydrogen and oxygen contribute to releasing energy in cells?
- How is energy shared out and used within cells?

SL statements C1.2.1–6. Textbook pp. 405–411.
Image: mitochondria in a mammalian lung cell, electron micrograph. Louisa Howard, public domain.



Objectives for each class

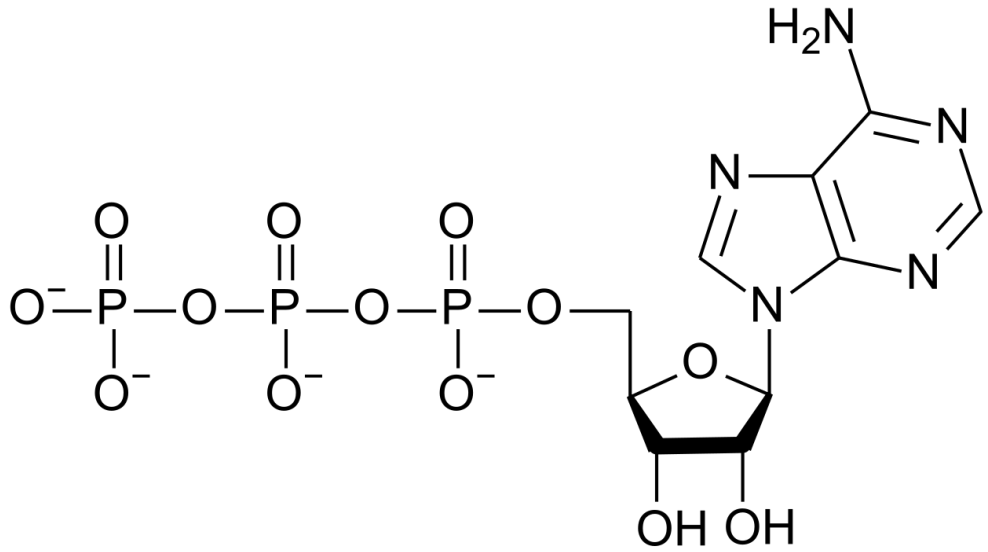
Class	Statements	By the end of the class, you can...
1	C1.2.1–2	Explain why ATP suits its role, and list the processes that it supplies
2	C1.2.3–4	Describe energy changes between ATP and ADP, and distinguish respiration from gas exchange
3	C1.2.5	Compare anaerobic and aerobic respiration in humans
4	C1.2.6	Use a respirometer, and calculate a rate of respiration

Overview of this chapter

Part	Statements	What it covers
The energy currency	C1.2.1–2	ATP, and what it is used for
Energy transfers	C1.2.3	ATP and ADP
The system	C1.2.4	Making ATP from carbon compounds
Two types	C1.2.5	Anaerobic and aerobic respiration
Measuring	C1.2.6	Variables, respirometers and rates

ATP distributes energy within cells

C1.2.1



Adenosine triphosphate. Mysid, public domain.

Property	Why it helps
Soluble	Moves easily within the cell
Cannot pass membranes	Stays where it is needed
Releases useful amounts	Enough energy for many tasks, and little wasted

- **ATP (adenosine triphosphate)** is a nucleotide
- It is called the energy currency: energy from respiration is passed to ATP and then spent on tasks in the cell

Key idea

Cells do not store much ATP. They make it where and when it is needed, and the same molecules are recycled over and over.

What ATP is used for

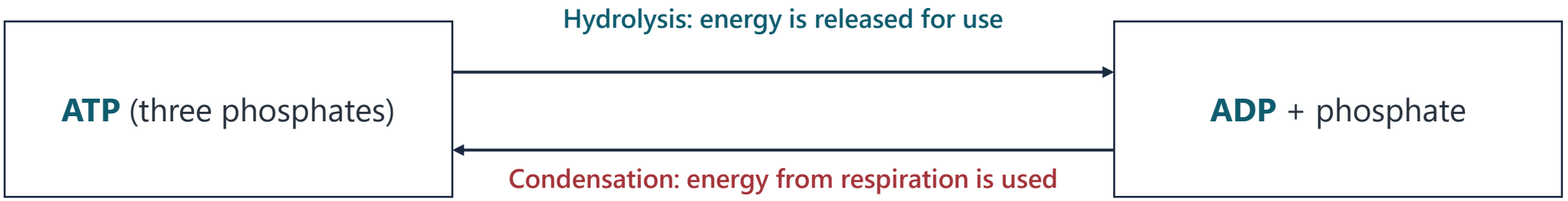
C1.2.2

Process	Examples
Active transport	Pumping ions across membranes, as at a neuron
Synthesis of macromolecules	Protein synthesis; DNA replication; making glycogen
Movement of the whole cell	Muscle contraction; beating of a sperm tail
Movement inside a cell	Chromosomes pulled to the poles; vesicles carried along

Common mistake

Do not write that ATP makes energy. ATP passes energy on to these processes. Some energy is lost as heat at each transfer.

Energy transfers between ATP and ADP



- Hydrolysis removes one phosphate, and releases energy
- Making ATP needs energy, which comes from respiration
- The energy released is sufficient for many tasks in the cell
- You do not need the quantity in kilojoules

Link

Hydrolysis and condensation are the same two reactions that you met for polymers in B1.1. Here water is again used up and released.

Respiration makes ATP

C1.2.4

- **Cell respiration** produces ATP, using the energy that carbon compounds release
- **Glucose** and **fatty acids** are the main substrates, but a wide range of carbon compounds can be used

	Cell respiration	Gas exchange
What it is	Chemical reactions that release energy from carbon compounds	Oxygen enters and carbon dioxide leaves the organism
Where	In the cells of all organisms	Across a surface such as an alveolus
Purpose	To produce ATP	To supply oxygen and remove carbon dioxide

Common mistake

Respiration is not breathing. Breathing helps gas exchange, which supplies respiration.

Anaerobic respiration in humans

glucose → lactate + a small yield of ATP

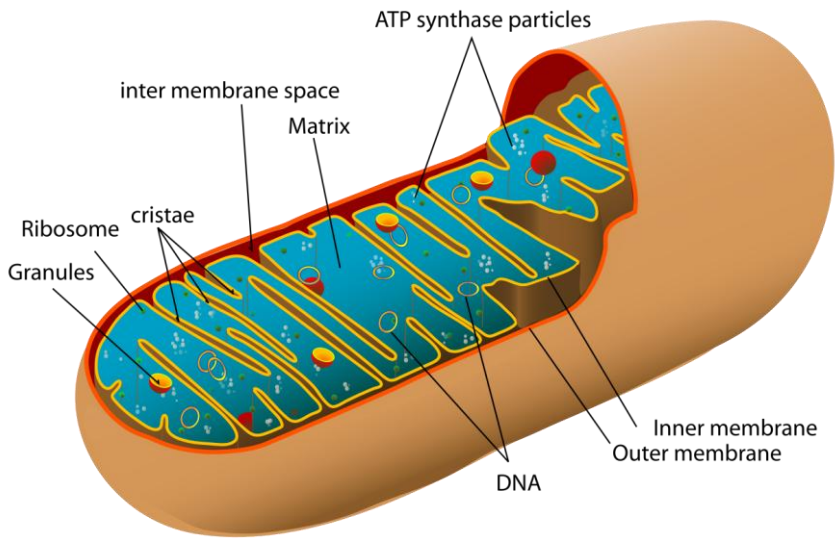
- No oxygen is required, and no mitochondria are needed
- It takes place in the **cytoplasm**
- Glucose is the substrate, and fatty acids cannot be used
- The yield of ATP is small, but it is produced quickly

When is it useful?

For short, intense activity, such as a sprint, muscles need ATP faster than aerobic respiration can supply it. Lactate builds up, and it lowers pH. After exercise, extra oxygen is used to remove it. This is why you keep breathing hard even after you have stopped running.

Aerobic respiration in humans

glucose + oxygen → carbon dioxide + water + a large yield of ATP



A mitochondrion. LadyofHats, public domain.

- It begins in the cytoplasm, and continues in the **mitochondria**
- Glucose or fatty acids can be used
- Oxygen is required
- The carbon compounds are **oxidized**, and the energy is used to make ATP

Key idea

Hydrogen is removed from substrates and finally passes to oxygen, forming water. This answers the first guiding question.

Comparing anaerobic and aerobic respiration

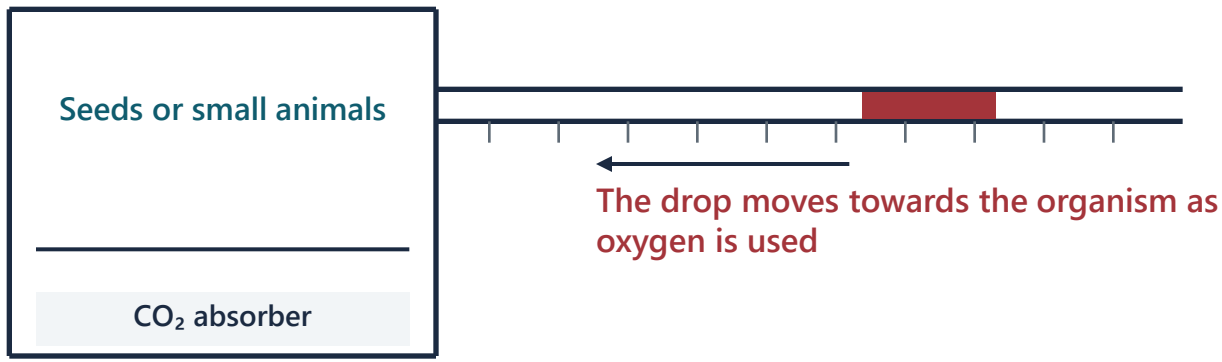
C1.2.5

	Anaerobic	Aerobic
Oxygen required?	No	Yes
Substrates	Glucose only	Glucose, fatty acids and others
Waste products	Lactate in humans	Carbon dioxide and water
Yield of ATP	Small	Large, many times greater
Where it occurs	Cytoplasm	Cytoplasm and mitochondria

Learn the two word equations too, with glucose as the substrate.

Measuring respiration with a respirometer

C1.2.6



Schematic, not to scale. Set up in a water bath.

- Organisms are sealed in with a substance that absorbs CO_2
- As oxygen is used, the volume of gas falls
- The change moves a drop of liquid along a scale
- A control tube has no organisms

Ethics

Animals in a respirometer are kept away from the absorber, which can harm them, and they should be returned to their habitat soon after. Seeds avoid many of these concerns.

Variables and rate calculations

C1.2.6



Germinating seeds. Ramjchandran, CC BY-SA 4.0.

- **Temperature**: higher temperatures raise the rate, until enzymes denature
- **Substrate**: the type and quantity available
- **Oxygen**: low concentrations limit aerobic respiration
- **Species and activity**: germinating seeds respire fast

Worked example

A drop moves 45 mm in 15 minutes, in a tube of cross-section 1 mm^2. Volume of oxygen = 45 × 1 = 45 mm^3. Rate = 45 / 15 = 3 mm^3 per minute. Dividing by the mass of the seeds, 5 g, gives 0.6 mm^3 per minute per gram, which lets you compare different samples.

Check that you can explain

1. Why ATP suits its role
2. Four uses of ATP
3. Energy changes between ATP and ADP
4. Respiration and gas exchange compared
5. Word equations for both types of respiration
6. A comparison of anaerobic and aerobic
7. How a respirometer works
8. How to calculate a rate from raw data

Exit activity: 5 minutes

On your own and without notes. Hand this in as you leave.

1. Write the word equation for anaerobic respiration in humans.

2. State two differences between anaerobic and aerobic respiration.

3. State the role of the CO_2 absorber in a respirometer.

Image credits

Mitochondria, mammalian lung – TEM.jpg – Louisa Howard – Public domain

ATP structure.svg – Mysid – Public domain

Animal mitochondrion diagram en.svg – Mariana Ruiz Villarreal LadyofHats – Public domain

Germinating seeds.jpg – Ramjchandran – CC BY-SA 4.0

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