2025 JUNIOR SCIENCE OLYMPIAD EXAM

JUNIOR YEAR 7 & 8

TO BE COMPLETED BY THE STUDENT. USE CAPITAL LETTERS.

First Name: ……...…..…… Last Name…….

Date of Birth: ……/……/...….

□ Male □ Female □ Unspecified

Year 7 □ Year 8 □ Year 9 □ Year 10 □ Other: …….

Name of School: ……..……..**State:** ……...

Examiners Use Only:

AUSTRALIAN SCIENCE INNOVATIONS

Junior Science Olympiad

2025 JUNIOR SCIENCE OLYMPIAD EXAM

7 & 8

Time Allowed

Reading Time: 0 minutes

Examination Time: 120 minutes

INSTRUCTIONS

- Attempt all questions in ALL sections of this paper.
- Permitted materials: non-programmable, non-graphical calculator, pens, pencils, erasers and a ruler.
- Marks will not be deducted for incorrect answers**.**
- There are four sections to the exam that focus primarily on Biology, Chem, Earth Science and Physics. In real science research, there are no hard boundaries between different disciplines, so you will see questions within each section that cross-over between different sciences. We encourage you to aspire to be an 'all-rounder' in your science understanding!

MARKS

- 1 mark for each question unless otherwise specified
- Total marks for the paper: 48

Integrity of Competition

If there is evidence of collusion or other academic dishonesty, students will be disqualified. Markers' decisions are final.

IUPAC Periodic Table of the Elements

1																	18
1 H hydrogen 1.0080 ± 0.0002	2		Key: atomic number **Symbol** name abridged standard atomic weight									13	14	15	16	17	2 He helium 4.0026 ± 0.0001
3 Li lithium 6.94 ± 0.06	4 Be beryllium 9.0122 ± 0.0001											5 B boron 10.81 ± 0.02	6 C carbon 12.011 ± 0.002	7 N nitrogen 14.007 ± 0.001	8 O oxygen 15.999 ± 0.001	9 F fluorine 18.998 ± 0.001	10 Ne neon 20.180 ± 0.001
11 Na sodium 22.990 ± 0.001	12 Mg magnesium 24.305 ± 0.002	3	4	5	6	7	8	9	10	11	12	13 Al aluminium 26.982 ± 0.001	14 Si silicon 28.085 ± 0.001	15 P phosphorus 30.974 ± 0.001	16 S sulfur 32.06 ± 0.02	17 Cl chlorine 35.45 ± 0.01	18 Ar argon 39.95 ± 0.16
19 K potassium 39.098 ± 0.001	20 Ca calcium 40.078 ± 0.004	21 Sc scandium 44.956 ± 0.001	22 Ti titanium 47.867 ± 0.001	23 V vanadium 50.942 ± 0.001	24 Cr chromium 51.996 ± 0.001	25 Mn manganese 54.938 ± 0.001	26 Fe iron 55.845 ± 0.002	27 Co cobalt 58.933 ± 0.001	28 Ni nickel 58.693 ± 0.001	29 Cu copper 63.546 ± 0.003	30 Zn zinc 65.38 ± 0.02	31 Ga gallium 69.723 ± 0.001	32 Ge germanium 72.630 ± 0.008	33 As arsenic 74.922 ± 0.001	34 Se selenium 78.971 ± 0.008	35 Br bromine 79.904 ± 0.003	36 Kr krypton 83.798 ± 0.002
37 Rb rubidium 85.468 ± 0.001	38 Sr strontium 87.62 ± 0.01	39 Y yttrium 88.906 ± 0.001	40 Zr zirconium 91.224 ± 0.002	41 Nb niobium 92.906 ± 0.001	42 Mo molybdenum 95.95 ± 0.01	43 Tc technetium [97]	44 Ru ruthenium 101.07 ± 0.02	45 Rh rhodium 102.91 ± 0.01	46 Pd palladium 106.42 ± 0.01	47 Ag silver 107.87 ± 0.01	48 Cd cadmium 112.41 ± 0.01	49 In indium 114.82 ± 0.01	50 Sn tin 118.71 ± 0.01	51 Sb antimony 121.76 ± 0.01	52 Te tellurium 127.60 ± 0.03	53 I iodine 126.90 ± 0.01	54 Xe xenon 131.29 ± 0.01
55 Cs caesium 132.91 ± 0.01	56 Ba barium 137.33 ± 0.01	57-71 lanthanoids	72 Hf hafnium 178.49 ± 0.01	73 Ta tantalum 180.95 ± 0.01	74 W tungsten 183.84 ± 0.01	75 Re rhenium 186.21 ± 0.01	76 Os osmium 190.23 ± 0.03	77 Ir iridium 192.22 ± 0.01	78 Pt platinum 195.08 ± 0.02	79 Au gold 196.97 ± 0.01	80 Hg mercury 200.59 ± 0.01	81 Tl thallium 204.38 ± 0.01	82 Pb lead 207.2 ± 1.1	83 Bi bismuth 208.98 ± 0.01	84 Po polonium [209]	85 At astatine [210]	86 Rn radon [222]
87 Fr francium [223]	88 Ra radium [226]	89-103 actinoids	104 Rf rutherfordium [267]	105 Db dubnium [268]	106 Sg seaborgium [269]	107 Bh bohrium [270]	108 Hs hassium [269]	109 Mt meitnerium [277]	110 Ds darmstadtium [281]	111 Rg roentgenium [282]	112 Cn copernicium [285]	113 Nh nihonium [286]	114 Fl flerovium [290]	115 Mc moscovium [290]	116 Lv livermorium [293]	117 Ts tennessine [294]	118 Og oganesson [294]

57 La lanthanum 138.91 ± 0.01	58 Ce cerium 140.12 ± 0.01	59 Pr praseodymium 140.91 ± 0.01	60 Nd neodymium 144.24 ± 0.01	61 Pm promethium [145]	62 Sm samarium 150.36 ± 0.02	63 Eu europium 151.96 ± 0.01	64 Gd gadolinium 157.25 ± 0.03	65 Tb terbium 158.93 ± 0.01	66 Dy dysprosium 162.50 ± 0.01	67 Ho holmium 164.93 ± 0.01	68 Er erbium 167.26 ± 0.01	69 Tm thulium 168.93 ± 0.01	70 Yb ytterbium 173.05 ± 0.02	71 Lu lutetium 174.97 ± 0.01
89 Ac actinium [227]	90 Th thorium 232.04 ± 0.01	91 Pa protactinium 231.04 ± 0.01	92 U uranium 238.03 ± 0.01	93 Np neptunium [237]	94 Pu plutonium [244]	95 Am americium [243]	96 Cm curium [247]	97 Bk berkelium [247]	98 Cf californium [251]	99 Es einsteinium [252]	100 Fm fermium [257]	101 Md mendelevium [258]	102 No nobelium [259]	103 Lr lawrencium [262]

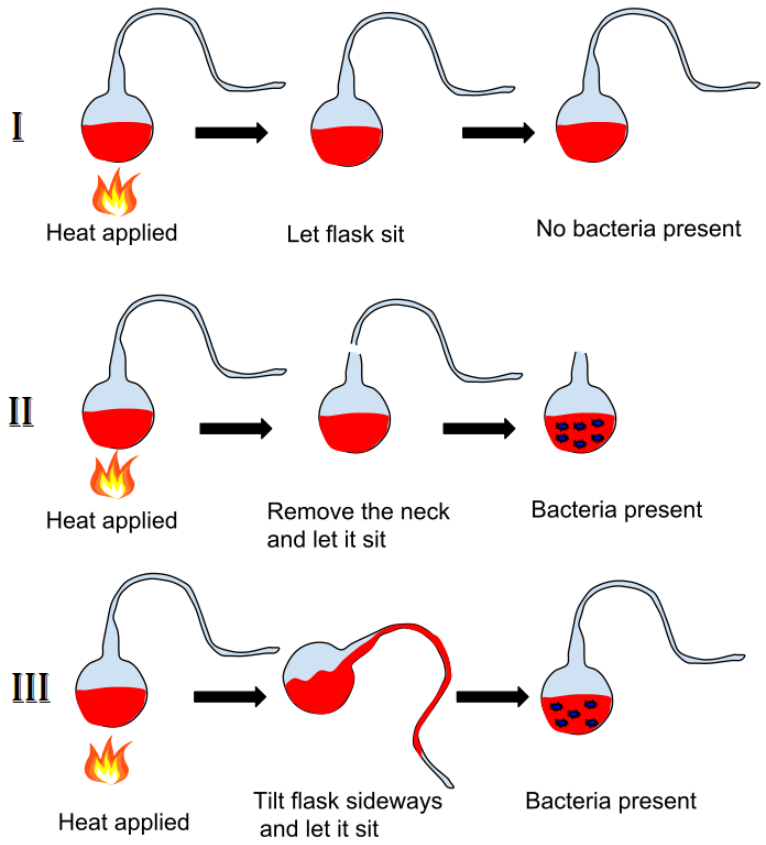
INTERNATIONAL UNION OF PURE AND APPLIED CHEMISTRY

For notes and updates to this table, see www.iupac.org. This version is dated 4 May 2022.

BIOLOGY

The information below relates to Questions 1 and 2

A key experiment in our early understanding of cell theory was conducted by Louis Pasteur. In the mid-1800s, Pasteur set up a series of experiments, aiming to show that germs were the likely cause of diseases, and that new cells came from existing cells. Pasteur's experiment entailed heating a growth medium for microorganisms, placing it in different conditions, and determining if any bacterial growth occurred. Pasteur's three main experiments are shown below.



Source: Wikimedia commons. Author: Kgerow16
https://commons.wikimedia.org/wiki/File:Louis_Pasteur_Experiment.svg

1	**(1 mark)** The main role of the heat in this experiment was: A. To add bacteria to the flask B. To provide a source of energy for the growth of microorganisms C. To regulate the temperature of the broth for the effective growth of microorganisms D. To kill any existing microorganisms in the broth, ensuring that any growth is from other microorganisms entering the system
2	**(1 mark)** Which of the statements below best describes the specific purpose of setup "II" in this experiment? A. To test whether bacteria is the microorganism which grows in the medium B. To test whether bacteria present externally can enter a sterile flask, and hence multiply in the growth medium C. To test whether bacteria in the neck of the flask can enter the solution and hence grow in the medium D. To test whether bacteria will grow in the medium if bacterial cells are not allowed to reach the medium at all

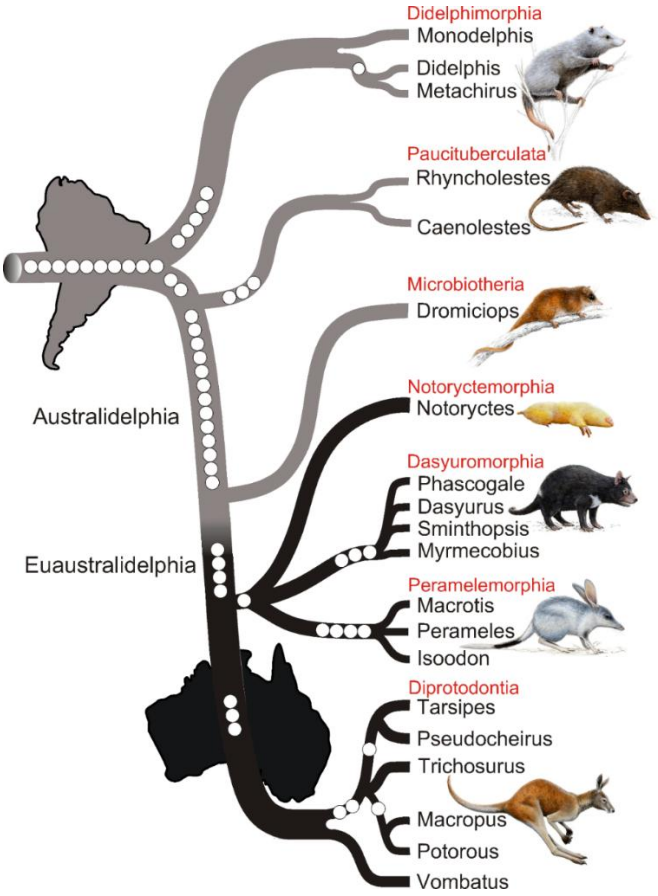
Info	***This information below relates to Question 3*** The Andean Condor is a species of vulture found in various countries in South America.  Source: Thomas Fuhrmann, Wikimedia commons https://commons.wikimedia.org/wiki/File:Andean_condor_%28Vultur_gryphus%29_at_Colca_Canyon.jpg A condor feeds primarily on dead and decaying animal carcasses. It builds its nests in elevated regions, such as in the Andes mountains. Condors have a ruff of white feathers around the base of their necks. Some males tend to have white patches on their feathers, whilst female condors tend to be smaller in size than the male.
3	**(1 mark)** Condors have evolved to have almost no feathers on their head and upper neck. Based on its appearance and lifestyle, what is the most likely benefit of this adaptation? A. Reduced air resistance and hence ability to reach high heights when flying B. Greater visibility to spot and hunt prey from a great distance C. Greater appeal of males to mating females and hence greater chance of reproductive success D. Reduced retention of bacteria and other microorganisms when feeding on animal carcasses

Info	***This information below relates to Questions 4 and 5***

Marsupials are a group of organisms found almost exclusively in Australia, including different species of kangaroo (genus: *Macropus*) and wombats (genus: *Vombatus*) and extinct animals such as the Thylacine (Order: *Dasyuromorphia)*.

Examples of marsupials found outside Australia include some species of opossum (order: *Didelphimorphia*) found in the Americas and the tree kangaroo (order: *Diprotontodia*) found in Papua New Guinea. Marsupials are believed to have first evolved in the Americas around 125 million years ago.

Today, the most diverse range of marsupials is found in Australia. The evolution of marsupials in Australia is depicted in the diagram below. Each branch indicates the divergence of a different order, family, genus or species, while the nodes indicate common ancestors.



Source obtained from wikimedia commons: https://commons.wikimedia.org/wiki/File:Phylogenetic_tree_of_marsupials_derived_from_retroposon_data_-_journal.pbio.1000436.g002.png Nilsson, M. A.; Churakov, G.; Sommer, M.; Tran, N. V.; Zemann, A.; Brosius, J. R.; Schmitz, J. R. (2010). "Tracking Marsupial Evolution Using Archaic Genomic Retroposon Insertions". *PLoS Biology* **8** (7): e1000436. DOI:10.1371/journal.pbio.1000436

4	**(1 mark)** Based on the image above, which of the following is the most accurate statement A. The branches “Potorus” and “Vombatus” shared a common ancestor more recently than “Potorus” and “Trichosurus” B. The branches “Dromiciops” and “Notorycytes” are more closely linked to each other than “Isoodon” and “Notorycytes” C. Of all the branches in the image, the order “Didelphimorphia” is likely to show the greatest amount of genetic differences when compared to Australian marsupials D. The order “Diprotodontia” is the only branch which relates to Australian marsupials
5	**(1 mark)** The best explanation for the widespread and diverse occurrence of marsupials in Australia is that A. They originated in the Americas and spread to Australia when the continents were once connected. Over time, they evolved to occupy different roles in Australian ecosystems B. They were introduced in Australia by early colonial settlers and rapidly grew in number and evolved to suit the Australian landscape C. An extinction event wiped out the marsupials in other parts of the world but created opportunities for Australian marsupials D. The introduction of other non-native mammals into Australian ecosystems by colonial settlers caused marsupials to adapt to occupy different functional roles in their ecosystems

6 **(1 mark)**

Trilobites are a group of ancient, extinct marine animals which have given evolutionary biologists many insights into early life on our planet. Fossil evidence has suggested that these organisms evolved as far back as 571 million years ago, and are believed to have gone extinct approximately 250 million years ago.

Source: Wikimedia commons. Author: Estonian Museum of Natural History
https://commons.wikimedia.org/wiki/File:Estonian_Museum_of_Natural_History_-_trilobite_-_Hydrocephalus.png

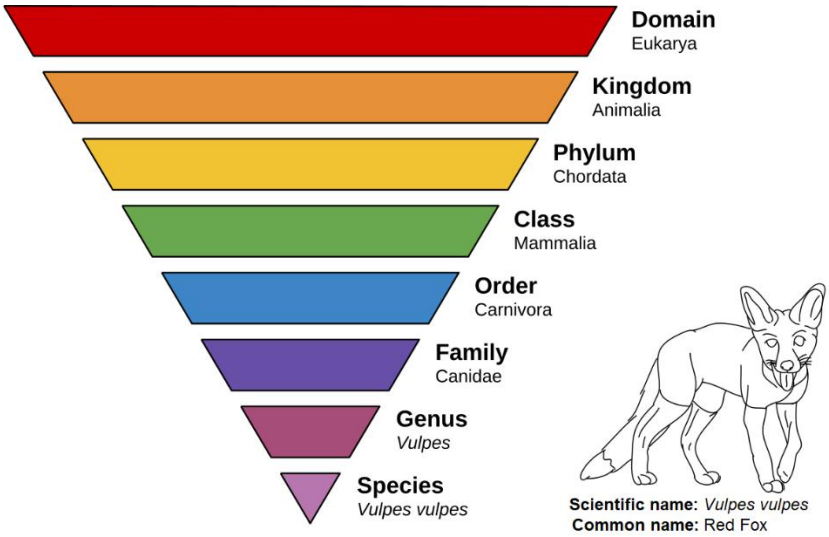
The classification of trilobites has been debated for years. Some taxonomists believe that trilobites should be classified within the phylum Arthropoda, while others suggest a separate, unique phylum due to distinct features in their exoskeletons and body segmentation. What does this debate in classification suggest about the challenges in taxonomy?

A. It reflects disagreements about the number of species within the phylum

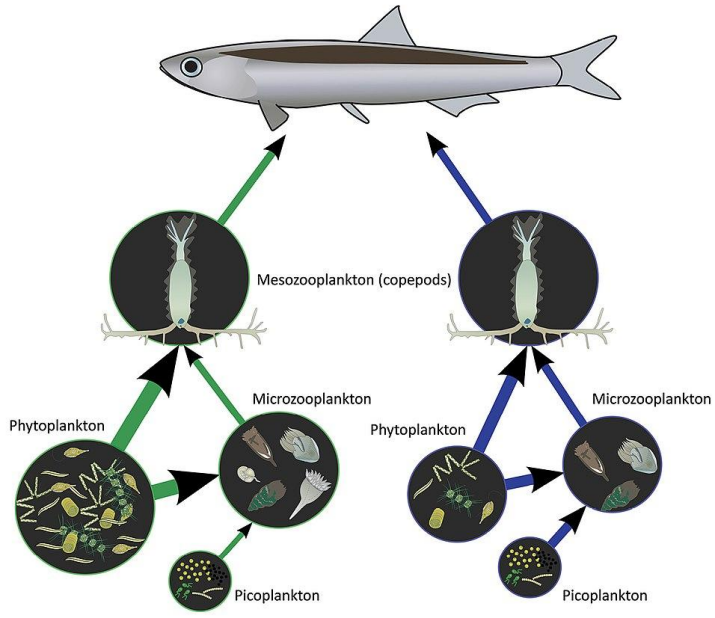
B. It highlights the difficulties of applying modern taxonomic principles to extinct organisms

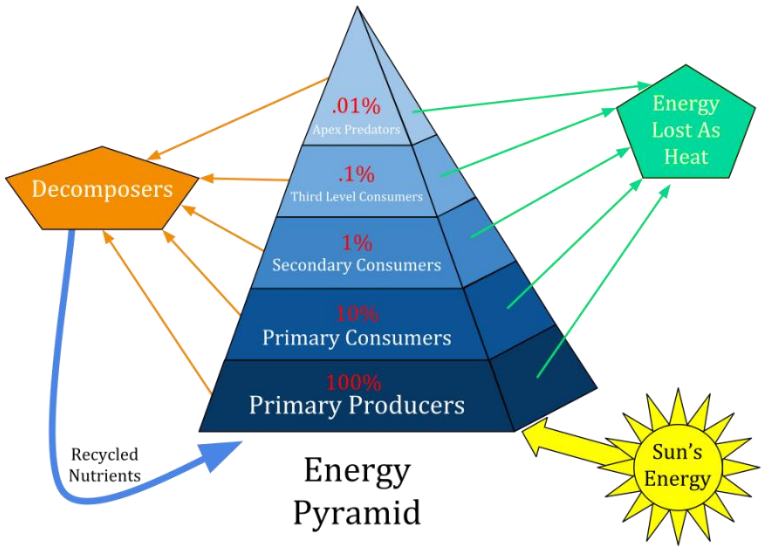
C. It indicates that the morphological features of trilobites are not useful for classification

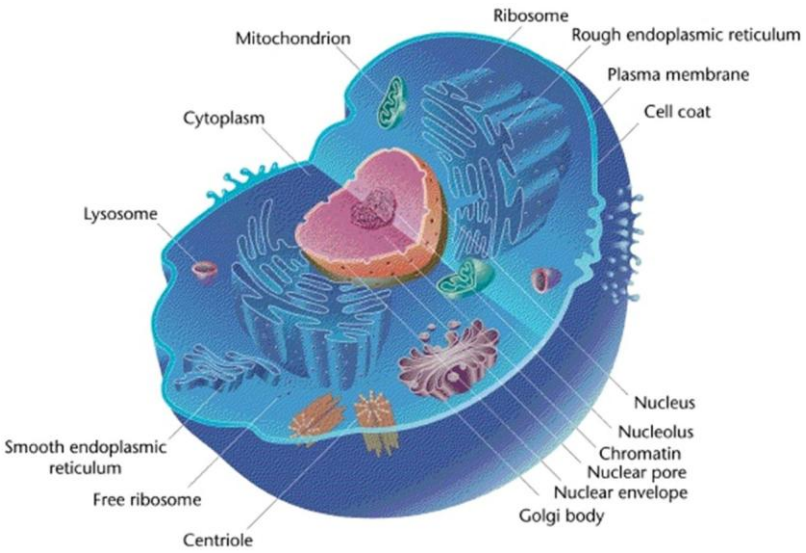
D. It shows that trilobites have always been classified as a single species

Info	***This information below relates to Questions 7*** Taxonomy is a form of classification which involves a hierarchical approach to grouping organisms based on their similarities and differences. Early forms of taxonomy relied primarily on anatomical characteristics. Since the discovery of DNA, taxonomy has increasingly considered genetic similarities and differences between organisms. Given below is the classification system as relevant to the red fox.  Source: Wikimedia Commons. Author: Annina Breen https://commons.wikimedia.org/wiki/File:Taxonomic_Rank_Graph_%28en%26la,ru%29.svg Organisms of the same species are generally seen as being capable of reproducing to produce viable young. The scientific name of a species is usually derived from the Genus and Species tiers. For instance, humans are deemed as *Homo sapiens* (Genus- *Homo*, species- *sapiens*). In some cases, the organism's genus and species name appear to be identical (e.g. the red fox, as shown above). The scientific name may also include the sub species designation, to distinguish from other organisms. For example, grey wolves are named *Canis lupus*, whilst domesticated dogs are named *Canis lupus familiaris* (sub species: *familiaris*). The dingo (scientific name: *Canis lupus dingo)* is a species native to Australia. In Australia, it is possible to find domesticated dogs, dingoes and red foxes, but not grey wolves. The red fox and European domesticated dogs were both introduced into Australia in the mid-1700s.

7	**(1 mark)** Based on this information, which of the following statements is least accurate? A. Dingoes and domesticated dogs evolved from grey wolves, either separately, or via a common ancestor B. Domesticated dogs are genetically more similar to the red fox than to the grey wolf C. Dingoes are genetically more similar to the grey wolf than to the red fox D. Domesticated dogs are likely to be able to reproduce with dingoes but not with foxes to produce viable young

Info	***This information below relates to Questions 8 and 9*** A food web is a diagram which shows the feeding relationships in an ecosystem. In a food web, arrows extend from an organism being consumed to the organism consuming it. The arrows are meant to show the flow of energy from one organism to the next. The diagram below depicts part of a food web, describing the food consumed by small fish in an aquatic ecosystem in the gulf of Naples. The food web was constructed using data from a study exploring the effects of nutrient levels. The circles on the left side give an indication of the number of organisms in eutrophic (high nutrient) conditions, while those on the right side show the number of organisms in oligotrophic (low nutrient) conditions. The size of the arrows gives an indication of the relative amounts of each organism which are available for consumption by the next level.  Source: Wikimedia commons. https://commons.wikimedia.org/wiki/File:Food_web_in_the_Gulf_of_Naples_in_eutrophic_and_oligotrophic_summer_conditions_-_oo_297117.jpg Zingone A, D'Alelio D, Mazzocchi MG, Montresor M, Sarno D, LTER-MC team (2019) Time series and beyond: multifaceted plankton research at a marine Mediterranean LTER site. In: Mazzocchi MG, Capotondi L, Freppaz M, Lugliè A, Campanaro A (Eds) Italian Long-Term Ecological Research for understanding ecosystem diversity and functioning. Case studies from aquatic, terrestrial and transitional domains. Nature Conservation 34: 273-310. https://doi.org/10.3897/natureconservation.34.30789

8	**(1 mark)** Based on this food web, which of the following statements is **LEAST** correct? A. An increase in microzooplankton would cause a subsequent decrease in picoplankton and phytoplankton and an increase in mesozooplankton levels B. Overfishing of small fish species would cause the mesozooplankton to increase in an uncontrolled manner and put pressure on lower levels in the food web C. The number and type of phytoplankton increases in high nutrient conditions D. The number and type of picoplankton increase during high nutrient conditions
9	**(1 mark)** A food chain is a diagram which represents one feeding relationship from the food web. Below is a food chain which is based on this ecosystem. **picoplankton → microzooplankton → mesozooplankton → small fish → large fish** Each stage in a food chain is called a trophic level. Typically, in a food chain, only about 10% of the energy available to any level is passed on to a subsequent level. This is illustrated in the energy pyramid below.  Source: Wikimedia commons. Author: Scann https://commons.wikimedia.org/wiki/File:Ecological_Pyramid.png

	Based on this information, which of the following statements is **LEAST** correct? A. Mesozooplankton would typically need to consume more food than microzooplankton, as mesozooplankton occupy a higher trophic level B. In this ecosystem, the number of large fish will typically be less than the number of small fish, due to the loss of energy along the food chain C. Any organism which feeds on the large fish would have a lot of energy available per gram of fish D. In this ecosystem, picoplankton is a primary producer and microzooplankton is a primary consumer
Info	***This information below relates to Questions 10*** Eukaryotic cells have a range of organelles which serve specific purposes. Below is a diagram of a typical eukaryotic cell and the role of some of its features.  Source: Wikimedia commons. Author: Mediran https://commons.wikimedia.org/wiki/File:Eukaryotic_Cell_%28animal%29.jpg

10 **(1 marks)**

Below is a list of key organelles and their function

Organelle / structure	**Function**
Nucleus	Contains the genetic material of the cell
Mitochondria	The powerhouse of the cell – energy release through cellular respiration
Ribosomes	Important role in protein synthesis
Cell membrane	Passage of substances into and out of cells

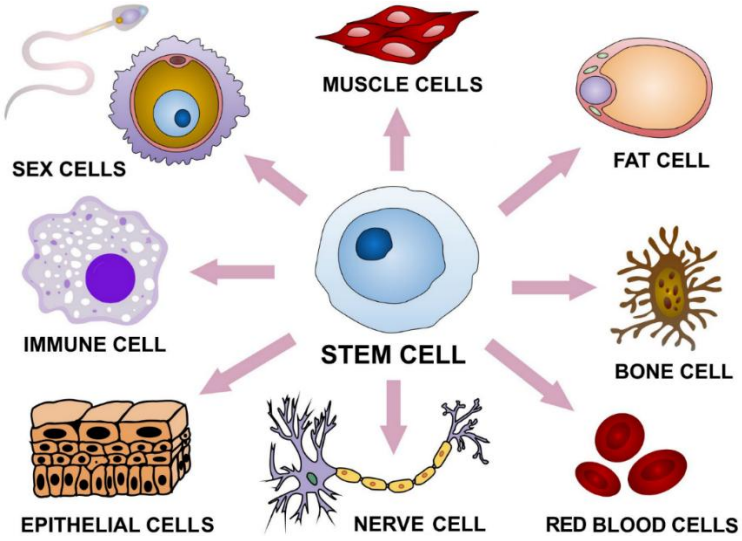
Which of the following features would you most expect to see in cells such as muscle cells which are required to undertake a large amount of work?

A. A large number of mitochondria

B. A large number of ribosomes

C. A large number of nuclei

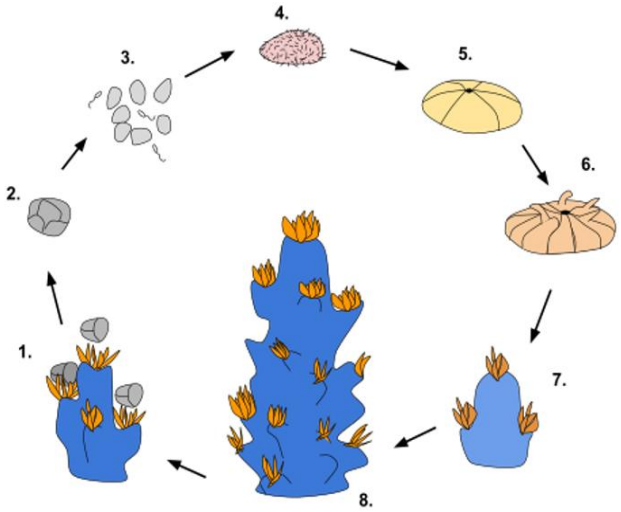
D. A large cell membrane

Info	***This information below relates to Questions 11*** The human body is made up of a range of different cell types, all of which originate from specific lines of stem cells. Whilst all cell types have similarities in their basic structure, they do have some key differences relating to their function. Some of these cell types are shown below (note: The sizes of each cell types are not shown to scale).  Adapted from: Wikimedia commons. Author: Haileyfournier https://commons.wikimedia.org/wiki/File:Final_stem_cell_differentiation_%281%29.svg

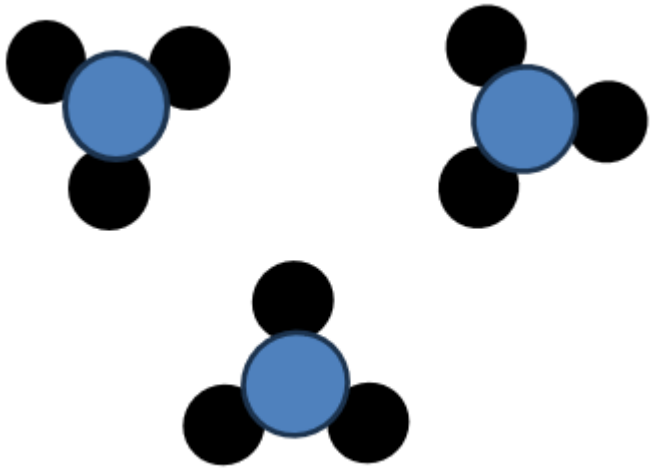
11 **(1 mark)**

Which of the following statements matches the description of the cell type to an **incorrect** structural feature linked to its function?

	Cell type	**Function**	**Structural feature**
A	Nerve cell	Transmit nerve impulses	Cell body branched into structures called dendrites to better receive signals
B	Red blood cell	Carry oxygen	Absence of nucleus which creates more capacity for carrying oxygen
C	Epithelial cell	Lining (e.g. skin)	Small cells which are easy to replace from lower layers if upper layers are damaged
D	Fat cell	To allow for storage of fats	Removal of all organelles to create more space for fat storage

Info	***This information below relates to Questions 12 and 13*** Corals are organisms which can employ a range of reproductive strategies. As shown below, sexual reproduction takes place when gametes from separate coral combine to establish new colonies.  Source: Wikimedia commons. Author: Andcelano. https://commons.wikimedia.org/wiki/File:Life_Cycle_of_Corals.svg Asexual reproduction normally occurs when polyps develop from mature coral and breakaway to expand or begin new colonies. Alternatively, fragmentation occurs when a section of coral falls away and establishes a new colony.
12	**(1 mark)** When comparing the genetic diversity of offspring and their parents, fragmentation is most similar to A. Polyp based asexual reproduction B. Sexual reproduction C. Equally different from sexual and asexual reproduction D. Not enough information to decide

13	**(1 mark)** Which of the following statements most accurately identifies an advantage and a disadvantage of the specific reproductive strategies mentioned in the statement? A. Advantage of fragmentation - results in the genes from the healthiest part of the coral forming offspring. Disadvantage of sexual reproduction - can result in traits from two separate coral being expressed. B. Advantage of sexual reproduction - results in a greater degree of genetic diversity. Disadvantage of fragmentation - enables a coral to form a new colony in another region, using a small part of its own structure. C. Advantage of sexual reproduction - generally requires more energy and resources. Disadvantage of sexual reproduction - relies on gametes joining together. D. Advantage of asexual reproduction - ensures that beneficial traits are almost certainly passed on to the next generation. Disadvantage of asexual reproduction - limits the amount of genetic diversity in offspring.

	CHEMISTRY
14	**(1 mark)**  *Pick the option which makes the sentence an accurate statement.* This diagram represents _____ because there is more than one type of atom making up each molecule. Answer: - Water - A compound - A mixture - An element - A pure substance - A solution

15 **(1 mark)**

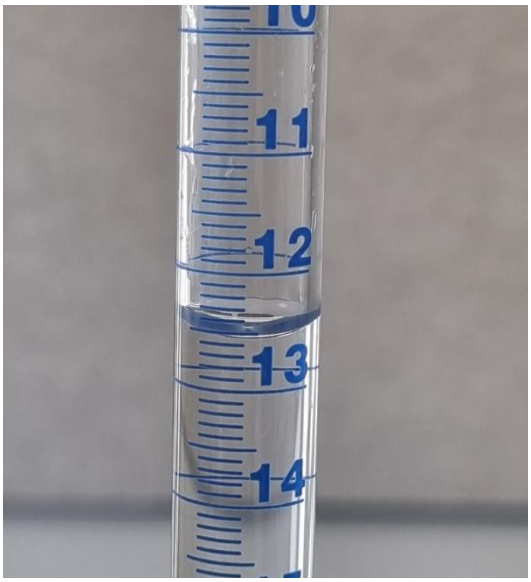
Source:
Icecream: Tobias Baur, Pexels; https://www.pexels.com/photo/close-up-shot-of-melted-ice-cream-on-cone-9887878/
Coffee: Picryl; https://picryl.com/media/appetizing-aroma-aromatic-food-drink-b299aa
Blue dye: Pickpik; https://www.pickpik.com/ink-water-water-glass-liquid-drip-flow-123481

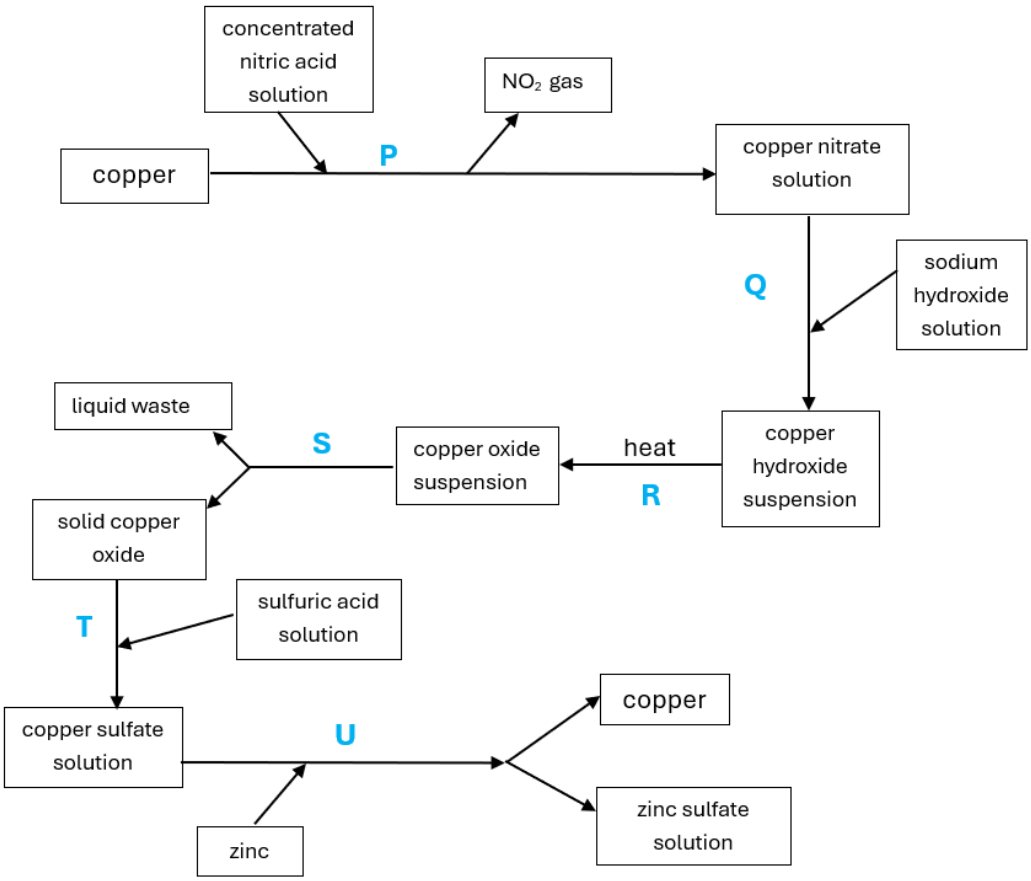
Read the following statements about the pictures.

I. The icecream is melting on the warm concrete.
II. The sugar cubes will melt into the hot coffee.
III. The blue crystals are dissolving into the water.

Which statements are true?

A. I only
B. I and II
C. I and III
D. All are true
E. None are true

16	**(1 mark)**  This photograph shows water in a glass cylinder marked in millilitres. To the nearest 0.1mL, what is the volume of water shown?

Info	***This information below relates to the following three questions (17, 18, 19)*** The flowchart below shows a series of separations and chemical reactions. The process starts with copper metal, which goes through steps P, Q, R, S, T and U. During the process, the copper atoms are incorporated into new substances, but when Step U is finished, they are recovered as copper metal again. 

17 **(1 mark)**

Copper nitrate is the product of procedure P. The formula for copper nitrate is $Cu(NO_3)_2$.

Which of the following correctly shows the number and type of atoms represented by this formula?

	Copper atoms	**Nitrogen atoms**	**Oxygen atoms**
A	1	2	6
B	1	1	6
C	1	1	5
D	0	0	3

18 **(1 mark)**

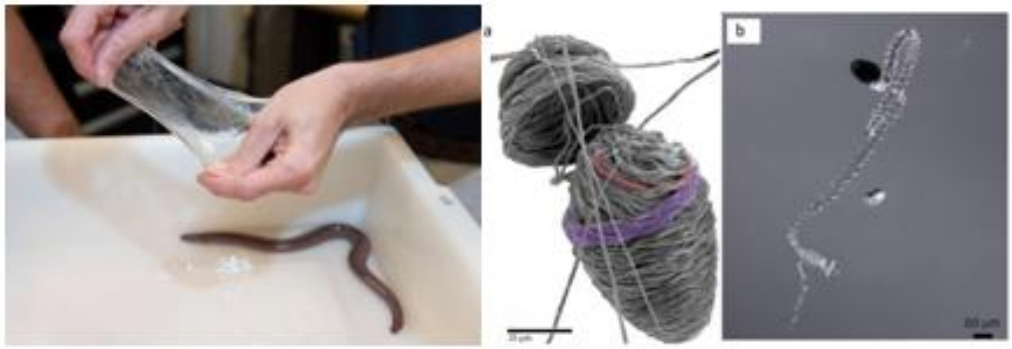
Identify which procedures were separations, and not chemical reactions.

A. Steps U and R
B. Steps R and S
C. Steps U and S
D. Step R only
E. Step S only

19 **(1 mark)**

The copper hydroxide suspension formed after step Q looks cloudy. Which is the best explanation for this?

A. The atoms forming the copper hydroxide are large enough to see individually
B. The copper hydroxide particles are fully dissolved and prevent light from passing through the beaker
C. The copper hydroxide particles have formed small lumps of solid material which are large enough to block light from coming through the liquid.
D. The copper hydroxide has filled the beaker so that it is no longer see-through.

20	**(1 mark)**  Figure 1: hagfish slime Figure 2a: Electron micrograph of protein strand (still coiled) from inside a gland thread cell Figure 2b: A protein strand in the process of uncoiling Source: Slime: Public domain: https://timelessmoon.getarchive.net/amp/media/dr-ryan-kincer-demonstrates-the-elasticity-of-the-authentic-pacific-hagfish-0f1ae8 Gland thread cell: *Cells* **2016**, *5*(2), 25; **https://doi.org/10.3390/cells5020025** When hagfish (also known as slime eels) are alarmed, they can create a large volume of slime around themselves in a very short period of time (Figure 1). They do this by squirting a fluid from special glands into the surrounding water. This fluid contains cells known as gland thread cells. Each cell contains an incredibly long strand of protein coiled tightly into the cell (Figure 2a). Released into water, the gland thread cells break open. The protein strands inside uncoil within a fraction of a second (Figure 2b) and tangle together to make a loose gel. A typical gland thread cell has a volume of about 0.0002 mm^3. The protein strand has the shape of a very long, thin cylinder. The radius of this cylinder is 0.0006mm. Assume that the volume of the protein strand is equal to the volume of the cell. Calculate the length (to the nearest millimetre) of the single protein strand from a gland thread cell of this size. Answer:

21 **(1 mark)**

Information about Bond Enthalpy

One of the signs of a chemical reaction is a temperature change. This happens because heat energy is either **absorbed** (making the surroundings cooler) or **released** (making the surroundings warmer.)

During a chemical reaction:

- Bonds in the reactant molecules must be broken to free up the atoms (which absorbs energy)
- New bonds are formed between the atoms to make the product molecules (which releases energy)

Each type of chemical bond has a specific **bond enthalpy** – this is the amount of energy it takes to break the bond. The same amount of energy is released when that bond is made.

Imagine atoms A and B. A and B can bond together to form three simple diatomic (two-atom) molecules: AB, A_2 and B_2. The bond enthalpies for these pairs of atoms are shown below.

Bond	**Bond enthalpy (arbitrary units)**
A-B (a chemical bond between an A atom and a B atom)	300
A-A	280
B-B	140

Which of the following reactions would have the overall effect of cooling the surroundings?

Reaction 1: $AB \rightarrow A + B$

Reaction 2: $2AB \rightarrow A_2 + B_2$

Reaction 3: $A_2 + B \rightarrow AB + A$

A. Reaction 1 only
B. Reaction 2 only
C. Reaction 3 only
D. Reactions 1 and 2

E. Reactions 1 and 3
F. Reactions 2 and 3
G. All three reactions

22 **(1 mark)**

Sam has accidentally mixed salt, sugar and naphthalene (the main ingredient in mothballs). These three substances have different solubilities in different solvents.

Based on the information below, what is the quickest way for Sam to recover the salt from the mixture?

Substance	**Soluble in water?**	**Soluble in ethanol?**	**Soluble in hexane?**
Salt	Yes	No	No
Sugar	Yes	Yes	No
Naphthalene	No	Yes	Yes

Pick the correct words from the drop-down boxes.

Add *(water/ethanol/hexane)* to the mixture, stir and filter, and then *(dry/evaporate)* the *(filtrate/residue)*.

Info

This information below relates to the following three questions (23, 24, 25)

The **rate** of a reaction is how fast it occurs. For instance, explosions – which happen very quickly – are chemical reactions with **high rates**.

A student was studying the reaction between magnesium metal and hydrochloric acid. Their aim was to determine how the concentration of hydrochloric acid affected the rate of the reaction.

They prepared five solutions of hydrochloric acid in beakers. The volumes they used are shown in the table below. They added an identical 0.2g piece of magnesium to each beaker and timed how long it took for the piece of magnesium to disappear. From the time value, they were able to calculate a rate.

They noticed that beakers 1 and 2 became slightly warm. For beakers 3, 4 and 5 it was hard to tell whether a temperature change had occurred.

Alex's results are shown below.

Experiment	**Volume of hydrochloric acid solution (mL)**	**Volume of water (mL)**	**Time taken for magnesium to disappear (s)**
1	50	0	11
2	40	10	16
3	30	20	20
4	20	30	32
5	10	40	didn't disappear

23

(1 mark)

How many times more concentrated is the acid in experiment 1 than that in experiment 4?

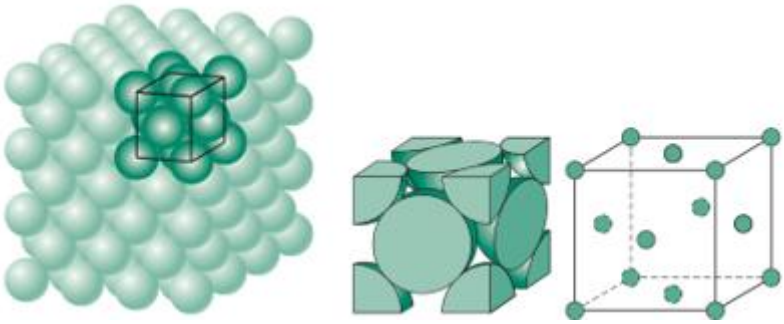
A. 2.5 times

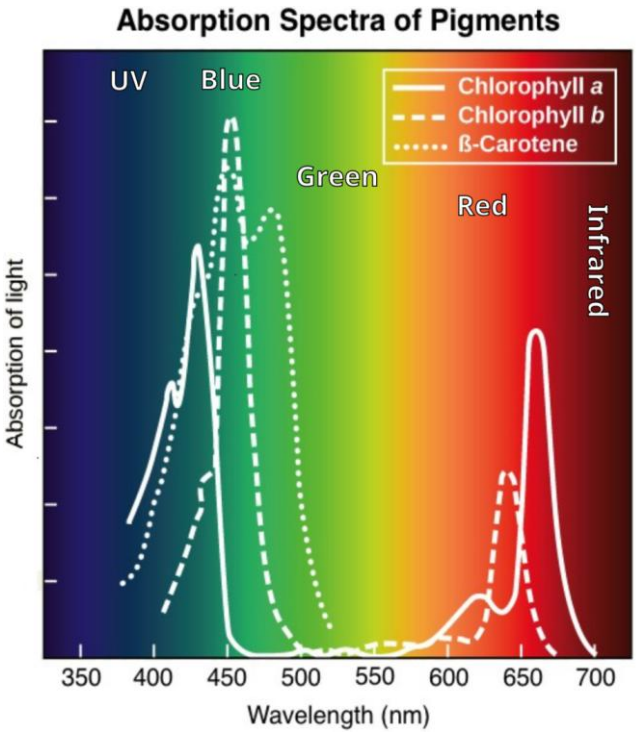
B. 2 times

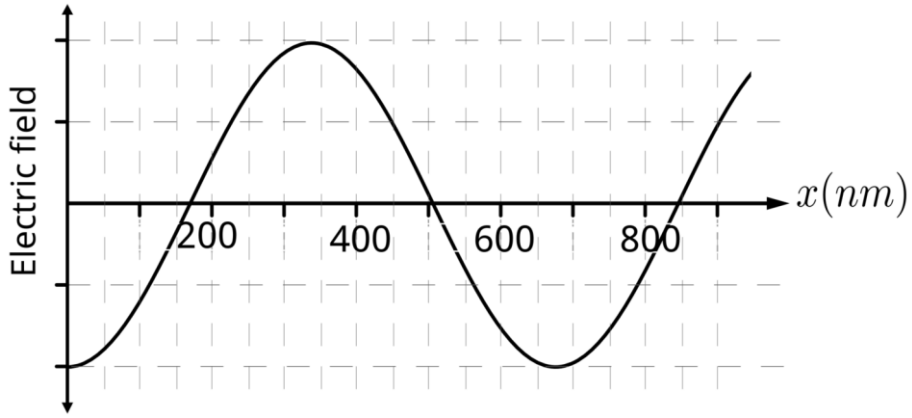
C. 1.5 times

D. 0.4 times

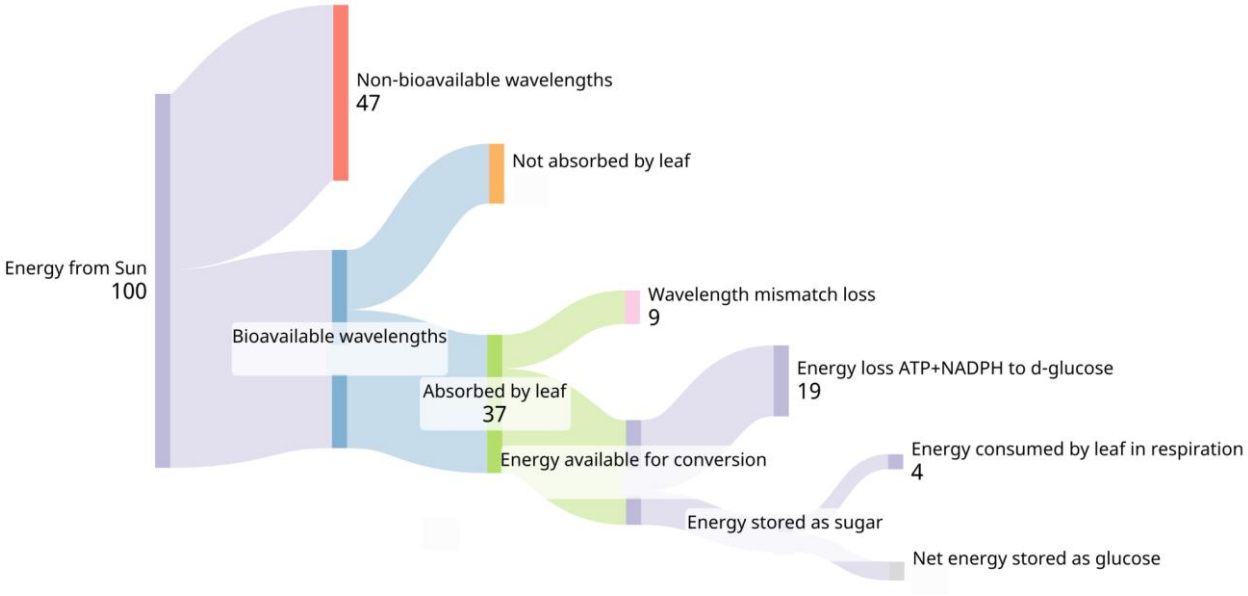
24	**(1 mark)** After determining the rate of the reaction in each experiment, the student wrote a conclusion based on their aim. Select words in the drop-down boxes to make this conclusion accurate. As the *(volume/concentration)* of *(hydrochloric acid/magnesium/water) (increases/decreases)*, the rate increases.
25	**(1 mark)** Select true or false for each of the following statements. • A 100mL beaker is the most appropriate piece of equipment to measure out the volumes of liquid. (True/False) • When the reactions in experiments 1-4 were complete, the solutions in the beakers still contained some acid. (True/False) • The total volume of the reaction solution is a dependent variable in this experiment. (True/False)

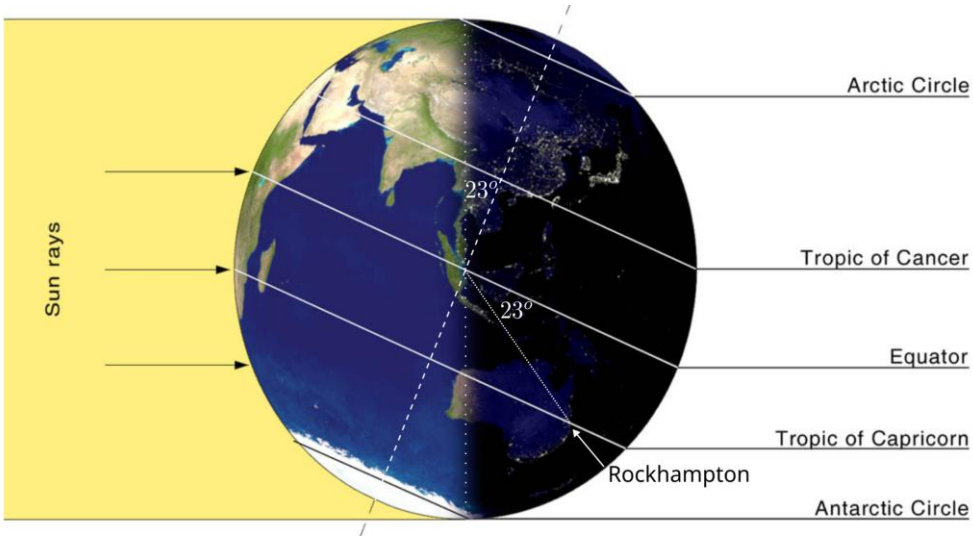
Info	***This information below relates to the next two questions (26 and 27)*** In iridium metal, the iridium atoms are arranged in a lattice (see Figure a). The geometry of this lattice is called 'face-centered cubic'. The darker atoms in Figure a indicate a single 'unit cell': this is the most basic unit that is repeated to make the larger lattice. However, each of the atoms in this unit cell is shared with at least one neighboring unit cell. If we slice down the faces of the unit cell to reveal only the portion of each atom that is within the unit cell, we get Figure b. Figure c shows the 14 atoms that contribute to one unit cell as small dots.  Figures a, b and c. Diagram: https://www.e-education.psu.edu/matse81/node/2133 CC BY-NC-SA 4.0
26	**(1 mark)** How many whole atoms are represented in a single unit cell? A. 4 B. 5 C. 10 D. 14

27	**(1 mark)** In iridium, each unit cell (Figure b) is a cube with a side length of 384 picometres (1 picometre is 1 trillionth of a metre). Based on the dimensions of the unit cell for iridium metal, calculate the radius of an iridium atom to the nearest whole picometre. Answer: _____ pm
	PHYSICS
Info	Absorption of electromagnetic waves by plants Visible light is a type of electromagnetic wave, which consists of oscillating electric and magnetic fields. The wavelength of a light wave is the distance over which a whole oscillation (cycle) of the electric field occurs. Different plant pigments can absorb light with a range of different wavelengths as shown in the graph below. $1nm$ is one millionth of a millimeter.  Image modified from "The light-dependent reactions of photosynthesis: Figure 4," by OpenStax College, Biology (CC BY 3.0)

28	**(1 mark)**  The light waves shown in the graph could be absorbed by: A. Chlorophyll a, Chlorophyll b and β-carotene B. Chlorophyll a and Chlorophyll b C. Chlorophyll a and β-carotene D. Chlorophyll b and β-carotene E. Chlorophyll a F. Chlorophyll b G. β-carotene H. None of the pigments
29	**(1 mark)** A carrot (which contains β-carotene but not Chlorophyll pigments) and a leaf (containing Chlorophyll a and Chlorophyll b but not β-carotene) are both illuminated with red light (i.e. light with wavelengths very close to 650nm). What colour will the carrot and leaf appear to be? **Carrot** (drop down list) Black Blue Red Green Orange

	Leaf (drop down list) Black Blue Red Green Orange
30	**(1 mark)** The energy of a particle of light (a 'photon') carries depends on the frequency of the light as $E = hf$ where h is an important constant in quantum mechanics called 'Planck's constant'. The units of the physical quantities on each side of an equation must always be the same. For example, if the units of distance is metres and the unit of time is seconds, then the units of velocity in $v = d/t$ must be m/s. Which of the following are correct statements about the units of Planck's constant and the energy of red and blue light? A. The units of Planck's constant are J/s and the energy carried by a photon of blue light is larger than the energy carried by a photon of red light B. The units of Planck's constant are Js and the energy carried by a photon of blue light is larger than the energy carried by a photon of red light C. The units of Planck's constant are J/s and the energy carried by a photon of red light is larger than the energy carried by a photon of blue light D. The units of Planck's constant are Js and the energy carried by a photon of red light is larger than the energy carried by a photon of blue light

31	**(1 mark)** A Sankey diagram shows the flow or change of some conserved quantity, such as energy, through a series of processes. The width of the arrows represents the amount of energy at each stage of the process. The Sankey diagram below shows the energy transformations that occur when 100 units of light energy from the sun falls on a leaf.  Data from: David Oakley Hall; K. K. Rao; Institute of Biology (1999). *Photosynthesis*. Cambridge University Press. ISBN 978-0-521-64497-6. Retrieved 3 November 2011. What is the efficiency with which the leaf can convert energy from the Sun into Net energy stored as glucose? _____% (Numerical answer)

Info	Apart from energy released inside the earth due to natural nuclear decay processes, all energy input to Earth arrives as electromagnetic radiation from the Sun. The distance from the Earth to the sun is much (much) larger than the radius of the Earth. The irradiance (power per square meter) varies over the surface of the earth as - the Earth is an oblate spheroid (that can be approximated as a sphere), and - is tilted on its axis at an angle of 23^o  Image adapted from: https://scijinks.gov/review/solstice/seasons/ (NOAA: https://www.climate.gov/faqs) There are two latitudes (measured as an angle south or north of the equator) at which the sun is directly overhead in the middle of the day in summer (the 'summer solstice'). These are the tropic of Cancer in the northern hemisphere (23^o above the equator) and the tropic of Capricorn in the southern hemisphere (23^o below the equator) A map of irradiance over the surface of the Earth is shown below.

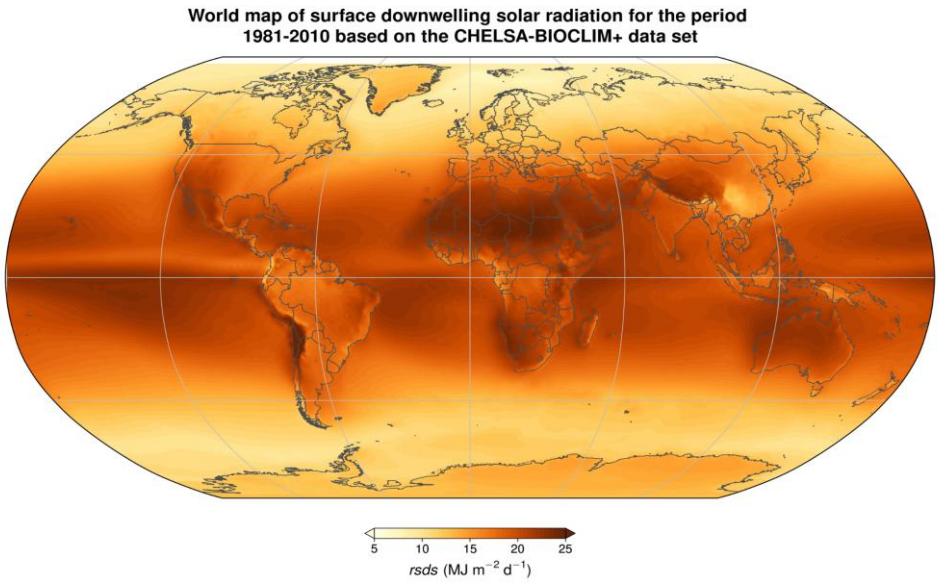


Image credit: By Greenmind1980 - Own work, CC BY-SA 4.0, https://commons.wikimedia.org/w/index.php?curid=120082457

32 **(1 mark)**

What is the main reason that areas closer to the equator receive higher solar irradiance than areas near the poles?

A. Areas of the Earth that are near to the equator are closer to the Sun than areas near the poles

B. The surface of the Earth near the poles is not perpendicular to the light arriving from the Sun

C. The Earth's tilt on its axis increases the average light that falls on equatorial regions

D. The polar regions reflect more sunlight than regions near the equator.

33	**(1 mark)** The Australian city of Rockhampton is situated close to the tropic of Capricorn. At the summer solstice the irradiance in the middle of the day is 1100W/m^2. A family in Rockhampton are considering purchasing solar panels for their flat roof. The commercial solar cells they plan to buy have an efficiency of 22% and each solar panel is 1.7m long by 1.0m wide. The family uses energy efficient 14W LED light bulbs in their house. If one of these solar panels were placed flat on the family's horizontal roof in the middle of the day on the summer solstice, how many 14W light bulbs could it power? A. 410 B. 219 C. 134 D. 85 E. 29 F. 17
34	**(1 mark)** Energy usage in Australia can be measured in kilowatt hours or joules. 1 kWh is equivalent to the energy transferred to a device that uses 1000 joules every second, if the device runs for 1 hour. The family in Rockhampton uses 25kWh on average each day, which is about average for Australian households. How many joules of energy does the family use on average each day? A. 90 million joules B. 36 million joules C. 3.6 million joules D. 90 thousand joules E. 25 thousand joules F. 2.5 thousand joules

35 **(1 mark)**

In the past, incandescent light bulbs were used for converting electrical energy to light. These devices use electrical energy to heat a wire filament to a high temperature so that it glows.

Just like the sun, incandescent light bulbs produce a range of electromagnetic wavelengths. As a light bulb is cooler than the sun, only a small fraction of this energy is produced at wavelengths that are visible to humans and useful for lighting.

An image of an incandescent light bulb in a table lamp (with the bulb pointing upwards) in infrared wavelengths is shown below. Infrared images can be used to determine the temperature of objects. Hotter areas of the bulb are coloured red, while cooler areas are shown in blue.

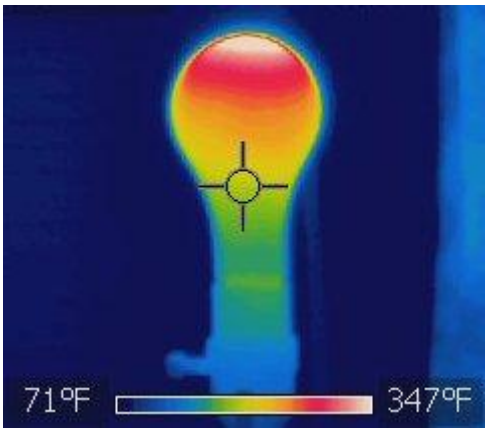


Image credit: By Zaereth - Own work, CC0, https://commons.wikimedia.org/w/index.php?curid=20400759

What is the best explanation for why the top of the bulb is hotter than the bottom of the bulb?

A. The hot filament is closer to the top of the bulb than the base

B. Heat is more readily conducted through the glass at the top of the bulb than the metal at the bottom.

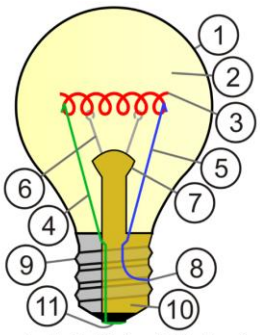
C. Air flows upwards around the base of the bulb, cooling it.

D. The filament is oriented so that it emits more radiant heat in an upwards direction than it does downwards.

36 **(1 mark)**

A labelled diagram of an incandescent bulb is shown below.

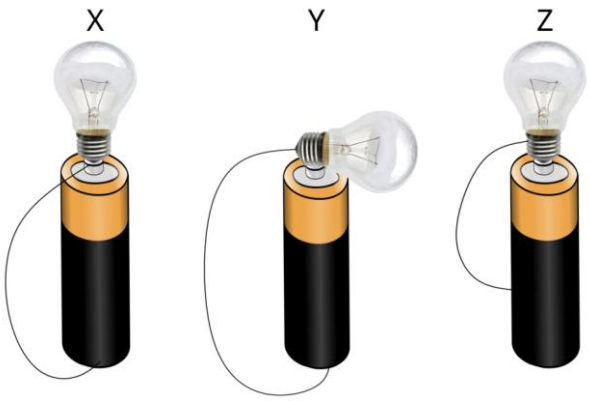
Credit: KMJ, alpha masking by Edokter, CC BY-SA 3.0, via Wikimedia Commons



Credit: Fastfission, Public domain, via Wikimedia Commons

1) Glass bulb
2) Low pressure inert gas (argon, nitrogen, krypton, xenon)
3) Tungsten filament
4) Contact wire A (carries current, goes into stem)
5) Contact wire B (carries current, goes out of stem)
6) Support wires (one end embedded in stem; no current)
7) Stem (glass mount)
8) Contact wire (carries current, goes out of stem)
9) Metal sleeve (electrically connected to contact wire B)
10) Insulation (vitrite, does not conduct electicity)
11) Metal electrical contact (connected to contact wire A)

Which of the following arrangements of a bulb, a battery and a conducting wire would light up the bulb?



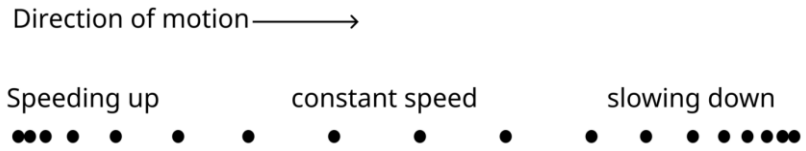
A. X, Y and Z
B. X and Y only
C. Y and Z only
D. X and Z only
E. X only
F. Y only
G. Z only
H. None

Info

*Information about **motion***

A **motion diagram** consists of dots showing the **position** of an object at **equal intervals of time**. If the distance travelled between dots becomes larger over time, then the object is speeding up, if the distance becomes smaller the object is slowing down.

Example: A motion diagram for someone running is shown below:



By measuring how far an object travels in a time period we can find its speed:

$$speed = \frac{distance\ travelled}{time\ taken}$$

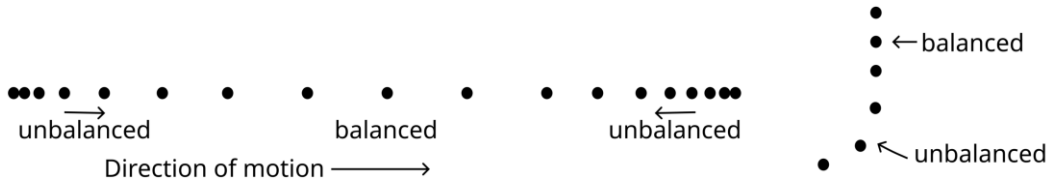
*Information about **forces***

Forces are pushes or pulls that act on an object. Examples of forces are the gravitational force (a 'non-contact' force); the force from a taut rope (tension); or from contact between the object and a surface (called 'friction' when the force is parallel to the surface and the 'normal' force when perpendicular to a surface)

If the forces on an object are **balanced**, then the object's speed and direction will stay constant (if speed = 0, it will remain zero)

If the forces are **unbalanced**, then the object's speed and/or direction of motion will change.

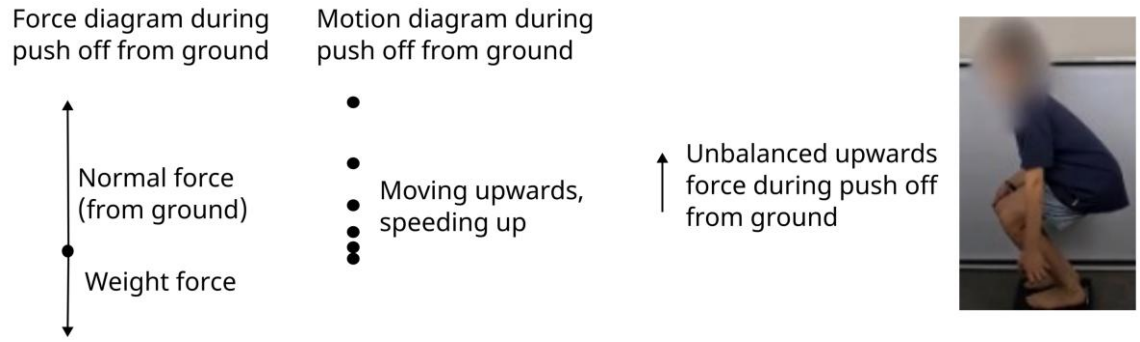
Example: We can tell whether the forces are unbalanced by examining an object's motion diagram. Wherever the distance travelled in each time period changes, or the direction of motion changes, then there must be an unbalanced force on the object. Wherever the spacing and direction remains constant, the forces must be balanced.



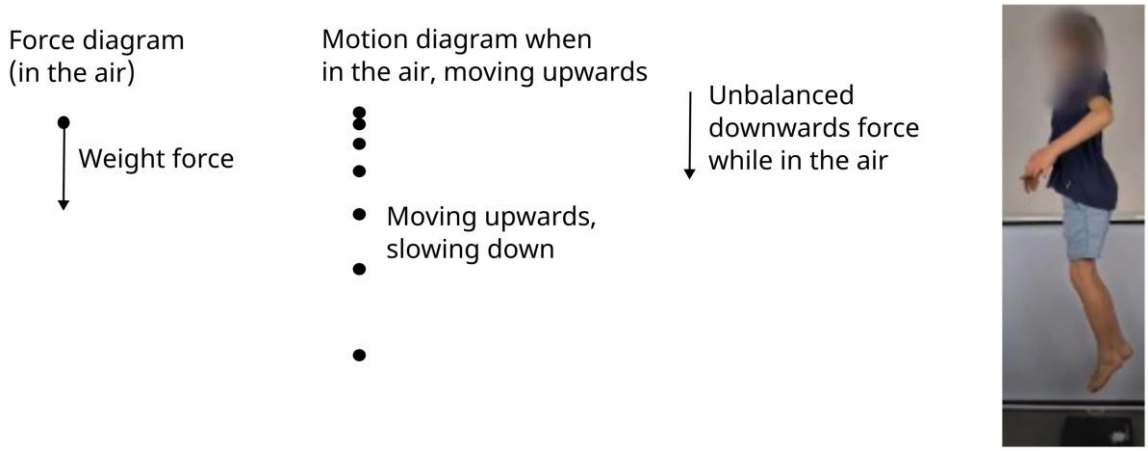
When more than one force acts on an object the net force is the sum of the forces, taking direction into account. A **force diagram**, which shows the direction and size of the forces acting on the object using arrows is a useful tool for analysing these situations. Force diagrams *only* include forces.

Example: The force diagram for a person as they jump upwards is shown below. While they are touching the ground there are two forces on them, a 'normal' force that acts upwards on the person due to the ground, and a non-contact force (their weight). These add (taking direction into account) to an **unbalanced** force upwards, so the person speeds up in the vertical direction.

The person creates the large upward normal force by pushing hard down into the ground with their feet (which pushes upwards on them with an equally large force).



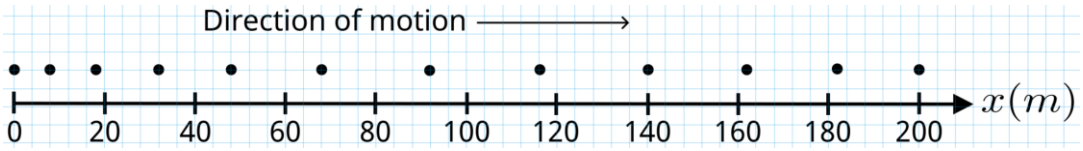
Once the person is in the air, if they are not touching anything, then the only force on them is their weight force. As this is an unbalanced *downwards* force they *slow down* while they move upwards.



Womens' 200m world record

The current world record in the women's 200m is 21.34 seconds, set by Florence Griffith-Joyner at the 1988 Summer Olympics in Seoul.

Below is a hypothetical motion diagram for an athlete running a womens' 200m race.

	
37	**(1 mark)** If the spacing between each pair of dots represents 2.00s, by how many hundredths of a second is the athlete behind world record time at the end of the race? Your answer should be an integer in the range 1-99 Answer: _____ hundredths of a second.
38	**(1 mark)** What is the athlete's speed between the 64m mark and the 140m mark? A. 8.8 m/s B. 9.7 m/s C. 10.9 m/s D. 12.7 m/s E. 15.2 m/s
39	**(1 mark)** At the times indicated, are the forces on the runner balanced or unbalanced? If they are unbalanced, in which direction is the unbalanced force? At times (Drop down for each): t=4.00s Balanced, Unbalanced (acting to the right), Unbalanced (acting to the left) t=12.00s Balanced, Unbalanced (acting to the right), Unbalanced (acting to the left) t=20.00s Balanced, Unbalanced (acting to the right), Unbalanced (acting to the left)

Info	**Parkour** In the discipline of Parkour, practitioners (traceurs) practice moving between two places in the most efficient way possible with no assisting equipment. When a traceur performs a 'wall run', they make contact with the wall with their feet and hands during the jump, finishing with their hands over the top of the wall.
40	**(1 mark)** A motion diagram for a traceur during a wall run is shown below.  (Credit for original video: Marco Gomes from São Paulo, Brasil, CC BY 2.0 <https://creativecommons.org/licenses/by/2.0>, via Wikimedia Commons https://en.wikipedia.org/wiki/File:Parkour_-_climb_stairs.ogv) The average height for a man in Brazil is 173cm. Use this fact to estimate the height of the wall the traceur climbs to the nearest 30cm. (https://en.wikipedia.org/wiki/Average_human_height_by_country) A. 1.8 m B. 2.1 m C. 2.3 m D. 2.6 m

E. 2.9 m
F. 3.2 m
G. 3.5 m

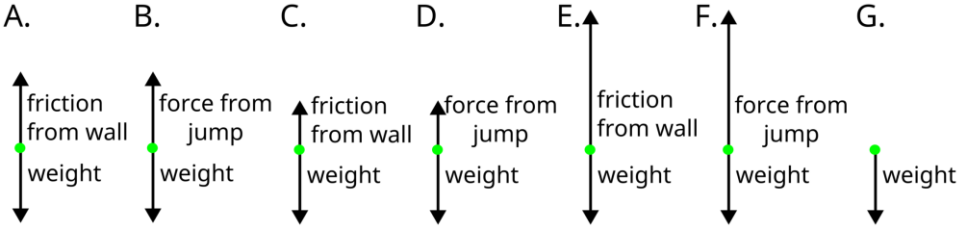
41 **(1 mark)**

Consider two specific positions on the motion diagram:

At position '11', the traceur is part-way up the wall. A vertical ruler has been provided next to the motion diagram.

At position '16' the traceur is moving upwards through the air and about to grab the top of the wall.

A number of possible force diagrams are shown below.

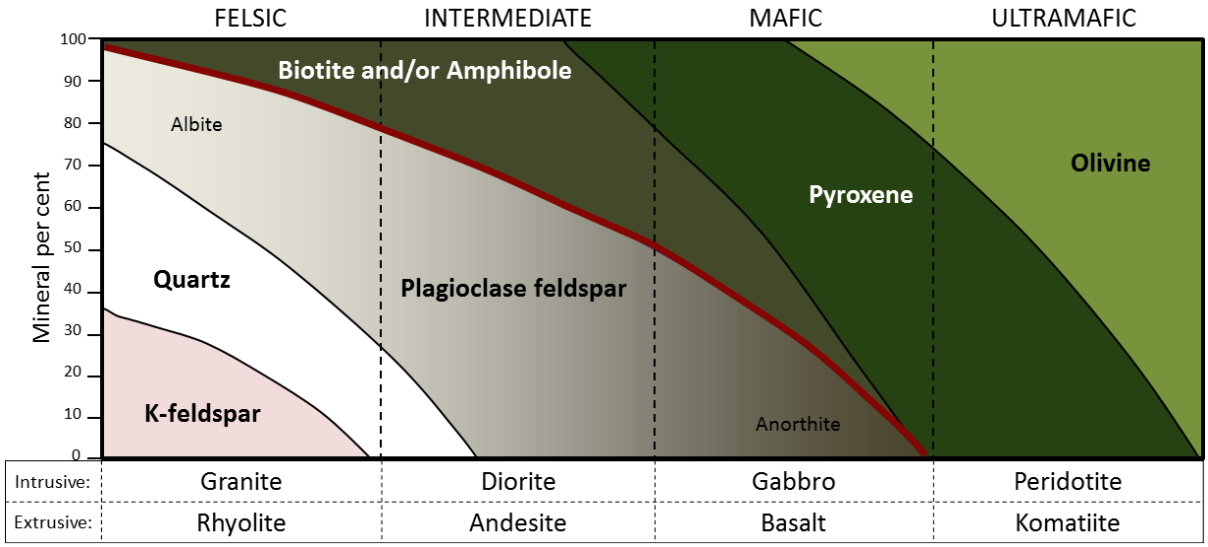


a) The correct force diagram for the position labelled '11' is: _____ (0.5 marks)

	b) The correct force diagram for the position labelled ‘16’ is: _____ (0.5 marks)

EARTH SCIENCE RESOURCES

Igneous rock classification by mineral composition.



- Volcanic (extrusive) rocks cool quickly at the surface and may not have a chance to develop many minerals to a visible size, with some minerals microscopic and some magmatic material cooling to non-crystalline glass. Gases escaping to the surface often form bubbles in the lava.
- Plutonic (intrusive) rocks cool slowly thousands of metres below the surface, under pressures too high for gases to form bubbles, and all magmatic material develops into visible crystals.
- Colour is not usually a good guide to mineral identification but Felsic rocks tend to be light colours because quartz is often white or clear and feldspars are usually white or pale pink.
- Mafic rocks tend to be dark colours because pyroxene and amphibole are usually very dark green or black. Lots of dark coloured minerals 'hide' the lighter coloured ones.
- Ultramafic rocks are usually distinctly green because olivine is always green or yellow-green.
- Intermediate rocks tend to be grey in colour, in between Felsic and Mafic!

Metamorphic rock table

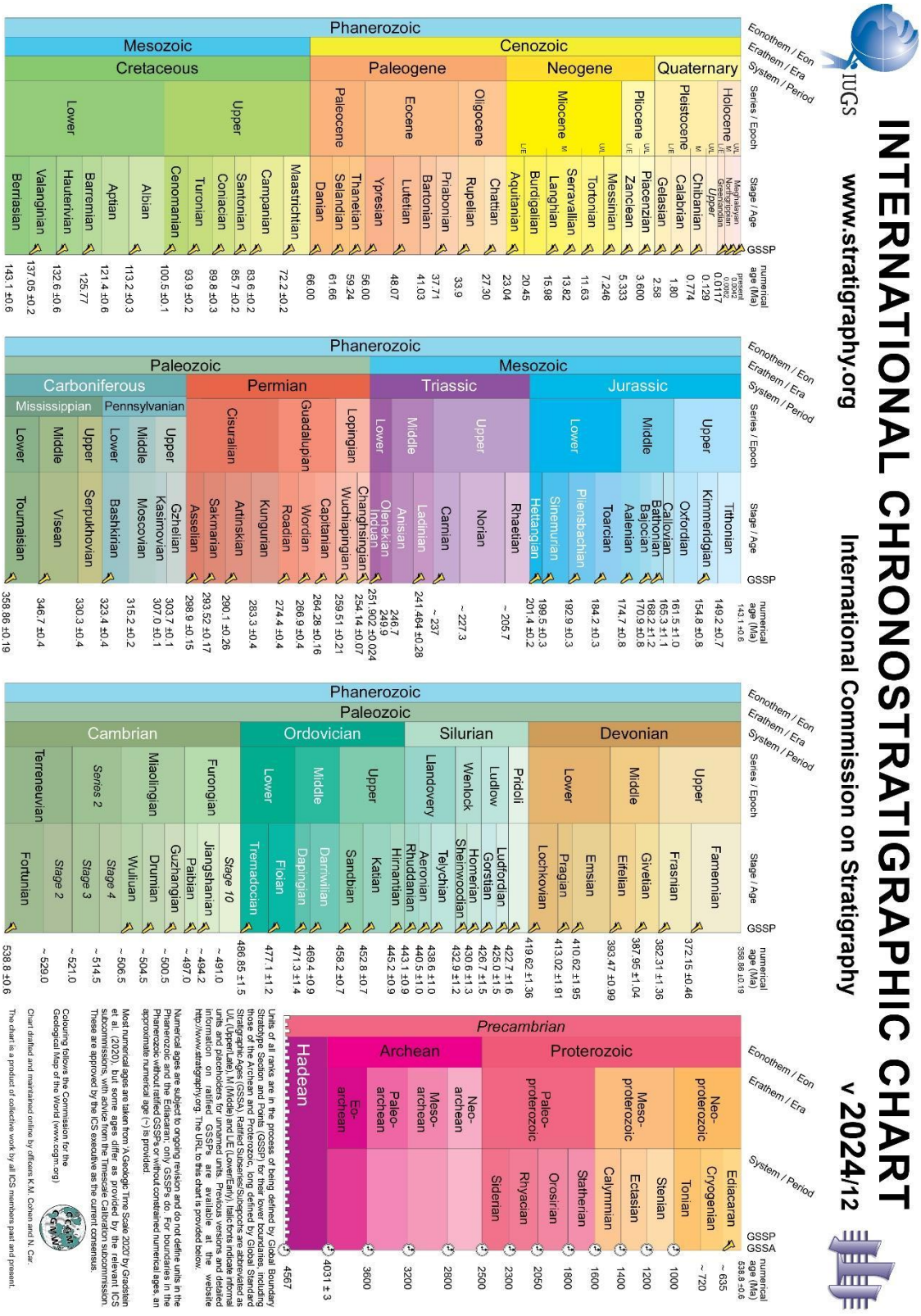
Starting rock		V Low Grade	Low Grade	Medium Grade	High Grade
Mudrock*	Regional Metamorphism	Slate	Phyllite	Schist	Gneiss
Granite		No change	No change	Almost no change	Granite gneiss
Basalt		Greenschist	Greenschist	Amphibolite	Amphibolite
		Regional metamorphic grade is based on a combination of temperatures and pressures, mostly found in tectonic collision zones. The higher the grade the higher both the temperature and pressure.			
Sandstone	Contact Metamorphism	No change	Little change	Quartzite	Quartzite
Limestone		Little change	Marble	Marble	Marble
Mudrock*		No change	Little change	Hornfels	Hornfels
*Shale is a mudrock with obvious layering. Mudstone is mudrock with no obvious layering.		Contact metamorphic grade is based on temperature changes at relatively low pressure, usually found adjacent to large igneous intrusions. The higher the grade the higher the temperature.			

A simplified guide to the types of metamorphic rocks that form from different starting rocks at different metamorphic grades. For example; *Greenschist* is a low grade regional metamorphic rock that forms when Basalt is the starting rock.

Sedimentary rock classification

<table>
<tr><th colspan="2">Granular sediment name</th><th>Grain size diameter</th><th colspan="2">Sedimentary rock name</th></tr>
<tr><td rowspan="3"></td><td>Large boulder</td><td>>630 mm</td><td colspan="2" rowspan="6">Conglomerate
or Breccia*</td></tr>
<tr><td>Boulder</td><td>200 – 630 mm</td></tr>
<tr><td>Cobble</td><td>63 – 200 mm</td></tr>
<tr><td rowspan="3">Gravel</td><td>Coarse gravel</td><td>20 – 63 mm</td></tr>
<tr><td>Medium gravel</td><td>6.3 – 20 mm</td></tr>
<tr><td>Fine gravel</td><td>2.0 - 6.3 mm</td></tr>
<tr><td rowspan="3">Sand</td><td>Coarse sand</td><td>0.63 - 2.0 mm</td><td colspan="2" rowspan="3">Sandstone</td></tr>
<tr><td>Medium sand</td><td>0.2 - 0.63 mm</td></tr>
<tr><td>Fine sand</td><td>0.063 - 0.2 mm</td></tr>
<tr><td rowspan="3">Silt</td><td>Coarse silt</td><td>0.02 - 0.063 mm</td><td rowspan="2">Siltstone</td><td rowspan="3">Mudstone
or
Shale</td></tr>
<tr><td>Medium silt</td><td>0.0063 - 0.02 mm</td></tr>
<tr><td>Fine silt</td><td>0.002 - 0.0063 mm</td><td>Claystone</td></tr>
<tr><td colspan="2">Clay</td><td>≤0.002 mm</td><td colspan="2"></td></tr>
<tr><td colspan="5">*Conglomerate has rounded grains; breccia has angular grains.</td></tr>
<tr><th colspan="2">Non-granular sediment name</th><th>Features</th><th colspan="2">Sedimentary rock name</th></tr>
<tr><td colspan="2">Lime-rich mud</td><td>High proportion of calcium carbonate mixed with clays</td><td colspan="2">Marl or Marlstone</td></tr>
<tr><td colspan="2">-</td><td>Mostly calcium carbonate materials from accumulations of shells, corals, etc</td><td colspan="2">Limestone</td></tr>
<tr><td colspan="2">-</td><td>Soluble minerals left behind when water evaporates from lakes and oceans.</td><td colspan="2">Evaporite</td></tr>
</table>

A simplified guide to the types of sedimentary rocks formed from granular material and other sedimentary rocks formed by the accumulation of materials in other ways. For example; a *sandstone* is formed by the compaction of sand grains deposited together by the movement of water or wind but a *limestone* can be formed by the on-site accumulation of carbonate materials, often the skeletons of corals and other marine creatures.



Info

Road trip

Friends Ruby Larenim and Jasper Enost love road trips, especially ones where they find fantastic landforms, geoscapes and fossils along the way. Find out about their latest adventure in the Ruby & Jasper diary: *Drive down-under!*

Excerpts from the travel diary of Ruby & Jasper (written by Ruby)

Drive down-under: Before we start!

What's a contour map? Here's a quick primer:

Contour lines join points of equal elevation, for example points at 10 m above seal level (asl), 20 m asl, etc. A map with set contour intervals will allow observers to discern the topography; valleys, hills and the gradient of slopes (see the example, Figure 1b, below).

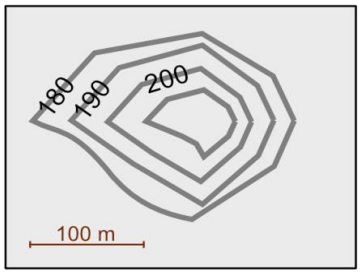


Figure 1a: An example of a contour map. By convention north is at the top of the map unless otherwise specified.

In this example the contour lines are 10 meters apart. The hill represented here is more than 210 m above sea level (asl) but less than 220 m asl. The horizontal scale, shown as a bar, is in metres.

Road cuttings

Also, as all Earth Scientists will tell you, road trips are great because engineers love to cut through hills to make the gradients easier for cars and trucks. The 'road cuttings' are wonderful windows into the geoscapes below the landscapes and are often the only places you get to see the geology that is normally covered by soil and forests or farmland crops.

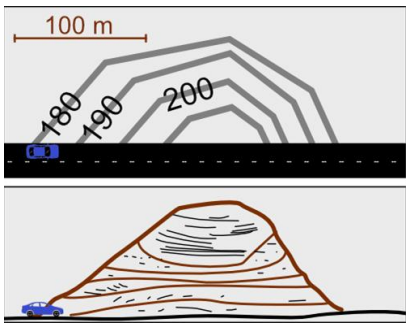


Figure 1b: An example of a road cutting.

The top image is a map, showing a road passing through the hill shown in Figure 1a.

The bottom image shows the road cutting, exposing all the interesting strata below the hill in cross-section. The road is relatively flat, saving all the effort of going up and over the hilltop!

Note: the vertical scale is exaggerated for clarity.

We have decided to ditch the GPS and try navigating by map, just for fun. What could possibly go wrong? Road maps are nice but a bit boring, so we have gone the extra mile (kilometre in Australia!) and purchased topographic maps that show the topography using contour lines as well as all the roads.

Drive down under: Flat or what?

We were told that Australia was flat! So far everywhere we have been there are hills. Even this interesting place we found (see Map, Figure 2, on next page) is hilly! It turns out, Australia isn't totally flat, it just is not as hilly as other places!

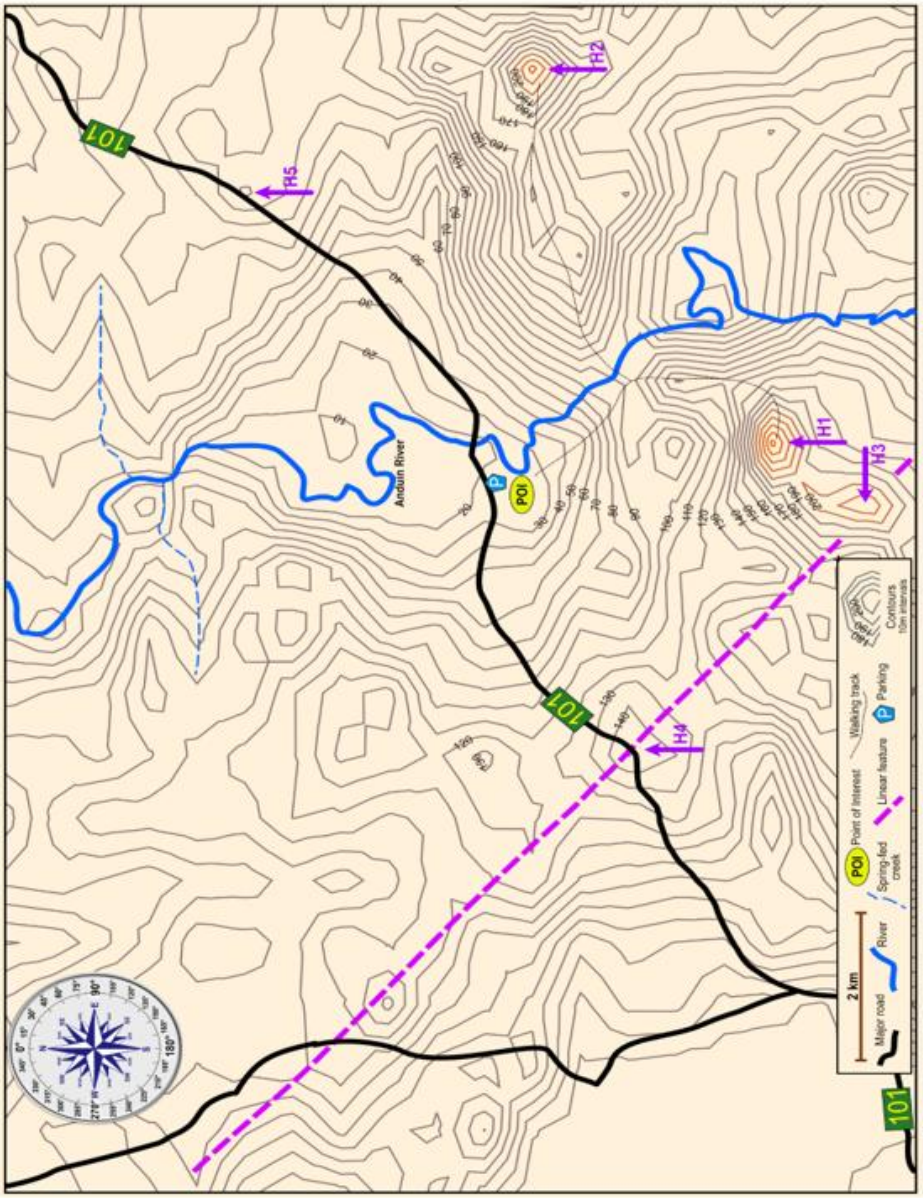
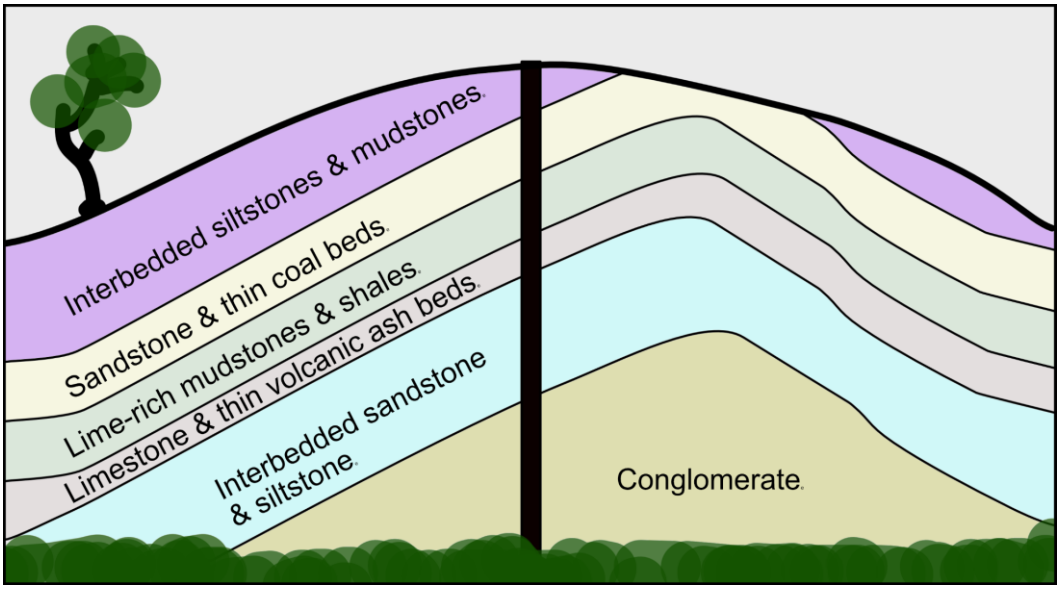


Figure 2: A piece of the Australian landscape Ruby and Jasper quite liked.

42	**(1 mark)** Travelling Highway 101, we decided to take a break at a picnic spot where the road crosses over the Anduin River (Figure 2). We found a camp ground adjacent to a billabong (also known as an oxbow lake), a natural feature only marked on the map as a Point Of Interest (POI). A sign indicated this billabong is a wetland habitat known to have been in place for many thousands years, based on carbon-14 dates taken on samples retrieved from the lake bottom. **As they ate their picnic lunch, what material did they decide might be found in the billabong/oxbow lake bottom sediments?** A. Mud, silt and fine sand from when the river occasionally floods. B. Pollen from plants in the region. C. Ash from bushfires. D. Human artefacts, made from a variety of materials including stone, wood, metal and plastic. E. Options A and B. F. Options B and C. G. Options A, B and C. H. Options A, C and D. I. Options B, C and D. J. Options A and C. K. Options C and D. L. Options A, B, C and D

43	**(1 mark)** Jasper and I were intrigued by the two high hills visible from the picnic area. One, almost due South, we called H1 and the other, almost due East, we called H2 (Figure 2). Both hills looked a bit barren on top. I decided to check out H1 and Jasper went to check out H2. Luckily there was a path to each hilltop with a handy foot bridge over the river for the trek to H2. We both found a very hard, fine grained, black-grey rock capping each hill. Using his phone's GPS Jasper determined the black-grey rock only outcropped above 210 m asl. My finding was the same for H1. The third hill, just to the Southwest of H1 that I am calling H3, also had a black-grey rock cap above 210 m. Furthermore, I identified weathered granite material on the ridge between H1 and H3. The granite was visible down to about 180 asl, below which the grass cover obscured everything. Jasper concurred, having noted granite visible on the ridge leading to H2 above about 170 asl. Back at camp we used our field kit to examine our samples of black-grey rock. Both samples exhibited numerous bubble-like cavities and a few visible glassy green minerals with no cleavage and a hardness of ~6.5. Otherwise they were featureless. **What did they conclude about the geology of the 3 hills?** A. The black-grey rock is a marble, formed by contact metamorphism of limestone when the granite intruded into it. Most of the marble has since weathered and been eroded away. B. The black-grey rock is a gabbro, formed from a different magma that formed the granite. The gas bubbles that were trapped as the intrusion cooled are always a feature of igneous rocks. C. The black-grey rock is a basalt, formed by lava that flowed over the weathered granite. Volcanic gas was trapped by the cooling lava as bubbles. Most of the lava flow has since weathered and been eroded away. D. The black-grey rock is a schist. It formed by the regional metamorphism of quartz sandstone when the granite intruded.

44	**(1 mark)** We were happy with our hilltop discoveries, but I was thrilled to see the linear feature on the third hill top, H3 (Figure 2). It was obviously the result of a very black rock that protruded slightly above the surface of the granite outcrops, like a tiny wall about two metres wide. Unlike the black rock capping the hills, it did not contain any bubble-like cavities. It appeared to be trending NW-SE. A quick look at satellite images of the area confirmed this linear feature extended across the landscape (Figure 2) but was not very distinct in most places. Road cuttings are often good places to see the geology in cross-section so we drove a short distance to a hill on the highway (Figure 2, H4). The best exposure, about 1000 m wide, was on the SE side of the cutting. I was pleased to see the vertical black rock in the outcrop was very obvious, confirming my suspicions that the rock is an igneous dyke (Figure 3). A dyke of this size, intruding into the cold rocks of the sedimentary sequence, could not heat the rocks enough to cause a wide zone of contact metamorphism. However, we did observe something of interest. See my field notes (Figure 4)!  Figure 3: A sketch of the road cutting outcrop, showing the dyke cutting through the folded sedimentary rocks at this location. The generic term for rocks being intruded is 'country rocks'. The limestone unit is very fine grained, showing no obvious fossils or clasts.

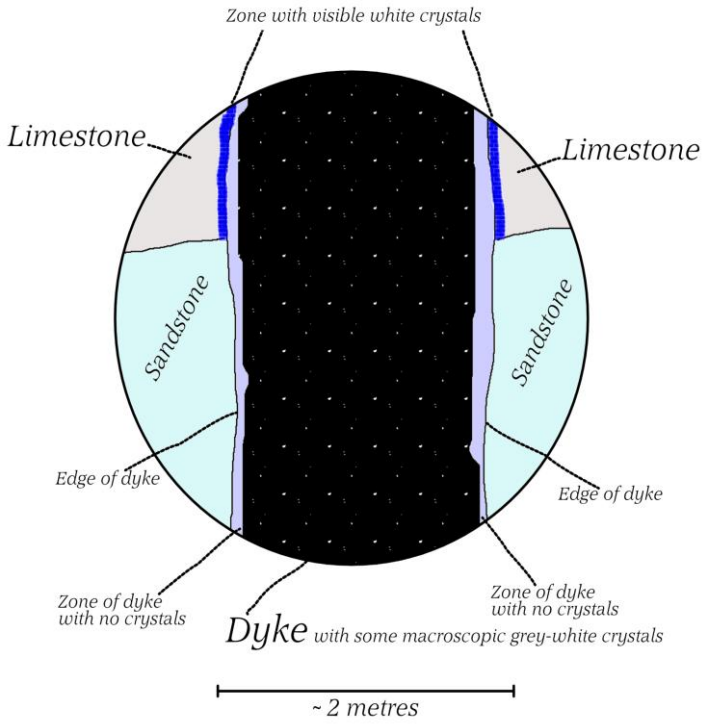


Figure 4: A sketch of some subtle features, visible at the road cutting where the dyke outcrop is in contact with the sedimentary rocks. The visible white crystals fizz with HCl, confirming they are $CaCO_3$

What else did they find where the dyke cuts through the sedimentary rocks?

A. The dyke has cooled more quickly at the edges, where it is in contact with the country rocks, than the rest of the dyke away from the edges.
B. The dyke has caused a tiny zone of contact metamorphism in some of the country rocks.
C. The dyke has caused no contact metamorphism in any of the country rocks.
D. The dyke has cooled more slowly at the edges, where it is in contact with the country rocks, than the rest of the dyke away from the edges.
E. Options A and B.
F. Options A and C.
G. Options D and B.
H. Options D and C.

45	**(1 mark)** That evening we camped next to the billabong. It proved to be a very clear night with spectacular views of the Milky Way. We spent the evening spotting planets, stars, meteors and satellites. We even saw the International Space Station zoom overhead! I fell asleep under the stars at about midnight, just as the Moon was rising. Jasper was bemused to see the Moon was still visible as we prepared to eat breakfast in the light of dawn. **How did Ruby explain this to Jasper?** *We had a dark sky before we fell asleep because the Moon phase was …* A. … a Last Quarter Moon, not a First Quarter Moon. B. … a First Quarter Moon, not a Last Quarter Moon. C. … a Full Moon, not a New Moon D. … a New Moon, not a Full Moon.

46 **(1 mark)**

We decided to camp longer at the site so we could explore the local geology a bit more, starting at another road cutting we saw on the way here (H5, Figure 2). The cutting is about 1000 m wide and has some wonderful rocks exposed for all to admire (Figure 6).

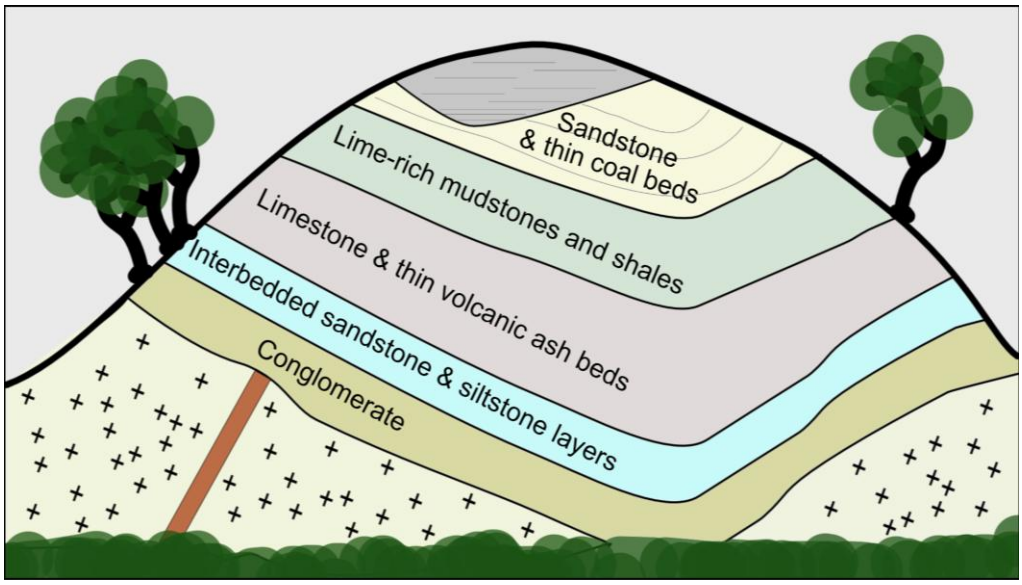


Figure 6 : Road cutting at H5, looking SE. The cutting is about 1000 m in width.

As we were admiring the vista, local farmer Herb Petani stopped to ask us what we were looking at.

Jasper was very excited by the intrusive rocks but I was more interested in the sedimentary rocks and the fossils they contained. Jasper explained to Herb that the rock at the bottom of the cutting was a granite intrusion.

What else did Jasper say to Herb about the granite?

A. It was once magma that pushed its way to the surface where it cooled quickly, after which it was intruded by a dyke and then overlain by sediments.
B. It was a magma that erupted onto the sea floor, where it cooled slowly, growing large crystals.
C. It was once magma that cooled slowly deep below the surface before being intruded by a dyke and then being exposed at the surface by lots of erosion.

	D. The hill was once a volcano and the granite is the rock that formed when the near-surface magma chamber finished erupting and the volcano went dormant. The other rocks in-filled the volcano's caldera.
47	**(1 mark)** I was very excited to show Herb the fossils I found in the rubble at the bottom of the road cutting. In it I found a tropical coral-rich Silurian rock, a Jurassic fern frond in some sandstone and a group of large Permian marine shells sitting in a slab of shale. **What else did Ruby say to Herb about the fossils and the road cutting?** A. Over time fast flowing rivers produced conglomerate deposits before depositing sand and silt as river flow rates dropped. A change in sea level produced a tropical shallow marine environment which in turn gave way to a shellfish-friendly muddy marine environment before returning to a swampy environment just above sea level. B. Over time an initial marine environment produced conglomerate deposits before depositing sand and silt as the climate changed due to increasing volcanism. This ultimately produced a shellfish-friendly muddy marine environment which in turn gave way to a shallow tropical marine environment before returning to a swampy environment just above sea level. C. The sequence represents a short period of time during which the local landscape was transformed from a flat expanse to a hilly area by mountain building tectonic processes. This is demonstrated by the sequence of fossils found in the strata found here. D. Over time an initial still water submarine environment transformed into a swampy environment just above sea level through a process of landscape evolution driven by climate change and plate tectonics. This is demonstrated by the sequence of fossils found in the strata found here.

48 **(1 mark)**

Herb was fascinated by the rocks and fossils and asked lots more questions. Jasper showed him a Rock Cycle poster (Figure 7) to help explain what had happened in the region over the last 500 million years.

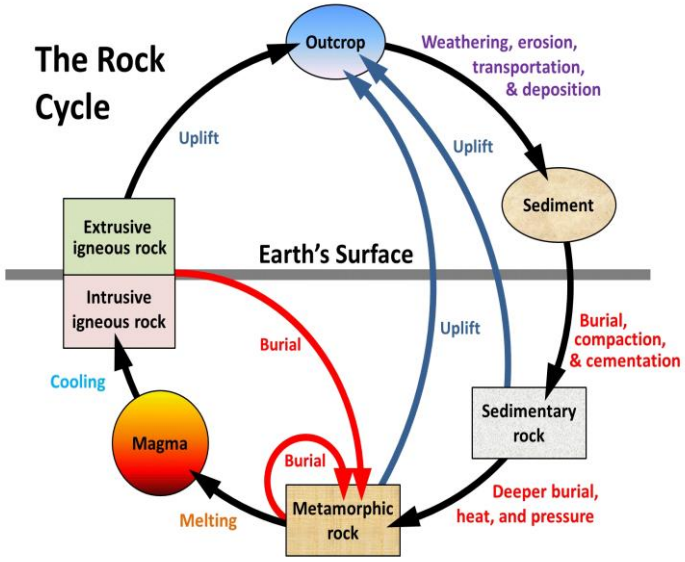


Figure 7: The Rock Cycle poster, courtesy of (© Steven Earle. CC BY)

While explaining the features seen in the road cutting outcrops at both H4 (Figure 3) and H5 (Figure 6) what else did Jasper have to add that is not shown in the poster?

A. The granite exposed at the base of H5 was formed by melting at a subduction zone during the Devonian.

B. The top of the hill at H5 is a Permian glacial deposit formed when Australia was over the South Pole.

C. The folding was caused by Plate Tectonic processes that compressed the rocks until they deformed sometime after the Jurassic.

D. The dyke seen at H5 was intruded during the rifting that formed the Australian and Antarctic continents in the late Cretaceous.

E. The volcanism recorded in the limestone unit was caused by Subduction Zone processes in the Ordovician.

F. The siltstones and mudstones outcropping on the surface of H4 are missing from H5 because of faulting in the Paleogene.