

Cambridge Entrance Exam

Biology ESAT

Engineering and Science Admission Test

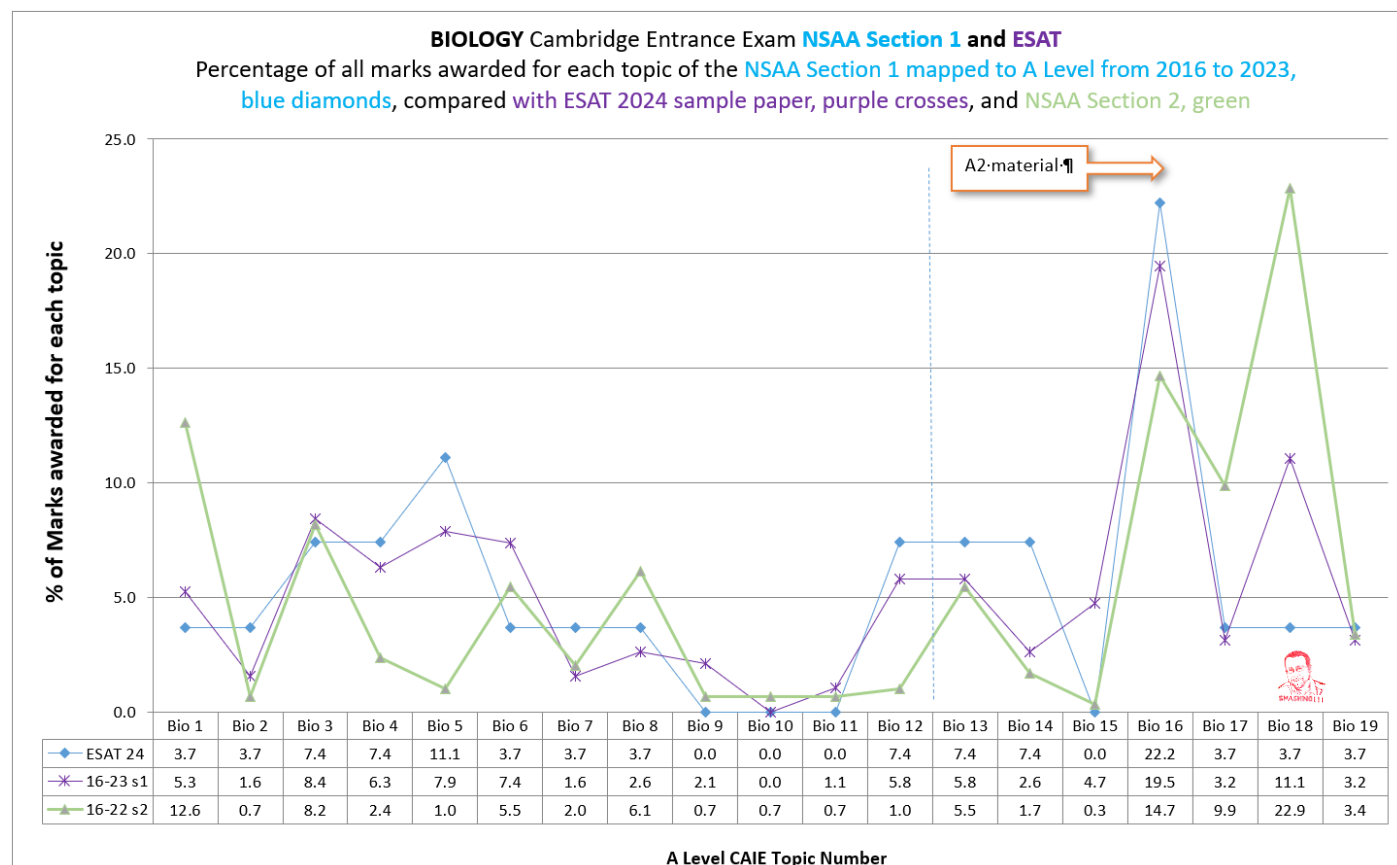
Past Exam Questions

Organised by A Level Topic

Specimen 2016 (NSAA) to 2024 (ESAT)

Name: _____

Class: _____



For digital version of this book (with active links)

As well as a wide variety of other free AS and A2 Chemistry resources, and some Biology resources, visit the website (www.SmashingScience.org) or scan this code:



A note on the BIOLOGY version of this revision book

Some things in this book, except the exam questions, are often mostly, and sometimes specifically, and occasionally, only relevant for Chemistry A Levels. But general trends, like the changes to UMS/PUM across time, are likely helpful to know about if you are instead focused on a Biology route into Cambridge's Natural Sciences degree.

For students who are interested in Oxford university, check if your course requires an entrance exam, most don't, if it does, it appears to be the BMSAT or possibly the PAT exams.¹ If you are really good at exams, then a route to Oxbridge through an entrance exam might be a better bet, but there are many other factors, most of which are discussed in this book: find out which path is best for you! Currently, as of June 2024 no specimen questions are presented on the Oxford website, but when they do become available later in 2024 something might appear on SmashingScience.

For any student interested in making a great top 20 university application than a lot that is in here EXCAPT the exam questions that can provide context and further background information about making your best UCAS application. If you have looked at the grade statistics in here and realise that you fit the grade profile than making an Oxbridge application is most likely worth doing. You should try to understand that success should be measured in the new skills you have learnt, and the things you are now better at. If you approach it as an opportunity for growth than you have nothing to lose in making an ambitious but less likely application (as well as 3 or 4 applications that are more likely to deliver you offers) a jolly good go will deliver powerful advantages, now and throughout a well lived life. If you don't quite have the grades but have been successful academically but have also overcome other challenges, for instance, you have spent time in local authority care, or are currently eligible for Free School Meals, or have been eligible in the last six years², then you definitely should think about applying.

For teachers there is a lot you can do with especially the easier past exam questions here, for instance introducing them as a starter and then teaching enough content in the lesson so that most students in the class leave the lesson able to answer a Cambridge entrance exam question That makes a great observed lesson. There is also a lot of information in here that may help you advise students through their UCAS process.

For parents and guardians there are a great many voices in this space. The official websites from the universities, colleges and departments are more reliable sources, but the general internet also has a great deal of information. The traditional approach is through careful selection of the school; for most students who would perform well at Oxbridge, complete choice of school is not usually possible. The UCAS process is about making the finish line as fair as possible: student A, at the end of the race is ahead of student B. But where and when the students start, and how much, and importantly, how effective, the help they get along the way varies wildly. A student who goes to a top 20 university may have achieved more than another student who gets an offer from Oxbridge, and that student from a less famous university could easily go on to have a more interesting, meaningful and successful life. Finding the time to find out what your child is doing, when they are doing it, and taking the opportunity to feel pride in the work that they are doing, and communicating those positive feelings to them, can address some of the more challenging feelings that working within any important but difficult process delivers. And it would also encourage and promote stronger achievement.

¹ <https://www.ox.ac.uk/admissions/undergraduate/applying-to-oxford/guide/admissions-tests>

² <https://www.undergraduate.study.cam.ac.uk/apply/after/contextual-data>
www.SmashingScience.org



To do checklist for making your greatest Oxbridge application

Tick ✓ each box when you've finished the task.

Learning about making a great UCAS application and this book	Silver - read it	Winner—thought about it (why is it included?)	Legend —revisited the idea a month later and talked about it with a teacher/parent/adult
Read this statement.	✓		
Understand that a great Oxbridge application involves a thorough understanding of alternate university degree courses that you can be happy and proud of completing, and with hard work, can deliver the same kind of life opportunities.			
Read about the deadlines and read the calendars at the back.			
Finished your first draft of your personal statement and talked to someone about it, ideally a teacher with experience with UCAS applications.			
Look at www.SmashingScience.org for other free resources, especially about Paper 1 MCQ.			
Understand why NSAA Section 1 is like the ESAT.			
Understand which topics are most important.			
Understand why most of your extended learning should be done becoming an expert at a topic before you try an NSAA question.			
Use the calendar to plan out the rest of the year until your last Oxbridge Interview.			
Spend 3 minutes each week thinking about which of your working time slots are productive, and which are not. Think about why they may have been different (e.g. first/last week after/before holiday, feeling unwell, Monday etc), and update your working schedule if these changes in your patterns are likely to be important next week.			
Used the graphs and tables to compare how the AS topics compare with the ESAT, and how the ESAT compares with the NSAA.			
Read each of the sections highlighted in <i>"Contents mapped to Cambridge's assessment of applicants list"</i> and using a calendar planned through how and when you are going to act to improve your chances and application across all these different assessment points.			
Thought about how you are going to get the best possible reference, and what you can do to help make that happen, including, perhaps, by completing the questionnaire at the back: <i>"Appendix: How to get the best reference"</i> .			
Thought about how the test being online now will affect your working on the exam questions. You are likely to have to write on lined paper to do your working and will enter your answers with a keyboard. This is very different compared to A levels and IB Diploma qualifications which all use paper exams, so your preparation should change to deal with this.			
Thought about what makes these questions harder than normal AS questions: more steps for each, more answer choices, tighter time allowance. Generally, these require a stronger approach to eliminating errors in your process, through a more systematic approach to showing yourself your thinking in your working.			
Thought about this whole UCAS process as a magnificent way to build invaluable skills in dreaming about, planning and then working towards the world's biggest goals that you will be able to use for the rest of your life at the most critical times, regardless of the outcome of your Oxbridge application.			



Contents mapped to Cambridge's assessment of applicants list

In addition to their various websites, and other formats of communication, Cambridge also delivers information through general feedback on individual applicants³, which provides an unusually complete list of what is used to compare applicants with each other. The order of the statements has been preserved and quotes from that have been used for this contents table.

For each of these resources, **after you have read them, write down the page number** next to the section heading. Highlight or underline whichever sections you find most important; the first two have already been done for you.

Method of assessment	Title of section in this book that provides some information
"Recent academic achievement, as evidenced by transcripts, GCSEs (or equivalent), AS-levels (where relevant), A-levels, or other school-leaving qualifications;"	<ul style="list-style-type: none"> • <i>UCAS entry requirements for some degrees that need Chemistry A Level (as of Nov. 2023). Page # ____.</i> • <i>UMS(/PUM) performance and the eventual HE destination of Cambridge applicants. Page # ____.</i> • <i>How does Cambridge process grades and UMS scores? Page # ____.</i>
"Contents of references and quality of predicted grades, where relevant;"	<ul style="list-style-type: none"> • <i>Top 15 performing UCAS Apply Centres in 2022 for Cambridge. Page # ____.</i>
"Quality of the personal statement, and evidence of interest in the subject to be studied and of engagement with that subject outside the classroom;"	<ul style="list-style-type: none"> • Appendix: Personal Statement advice and information. Page # ____.
"Performance in admissions assessments, where relevant;"	<ul style="list-style-type: none"> • <i>Comparing marks allocated to each topic . Page # ____.</i> • <i>Section 1 Questions . Page # ____.&</i> <ul style="list-style-type: none"> ◦ <i>Section 1 Mark Scheme. Page # ____.</i> • <i>Appendix: ESAT syllabus mapped to CAIE A Level Biology</i> • <i>Section 2 Questions . Page # ____.&</i> <ul style="list-style-type: none"> ◦ <i>Section 2 Mark Scheme. Page # ____.</i>
"Quality of submitted work, where relevant;"	<p>[No work is required to be submitted for most science subjects, with the exception of Psychology at Cambridge:]</p> <ul style="list-style-type: none"> • <i>University of Cambridge Science Subjects Entrance Exams. Page # ____.</i>
"Performance at interview;"	<ul style="list-style-type: none"> • <i>Appendix: Degree subjects which require interviews. Page # ____.</i> • <i>Appendix: Organising your interview preparation. Page # ____.</i>
"Performance in standardised tests of English language proficiency such as IELTS, where relevant;"	<ul style="list-style-type: none"> • <i>Appendix: Performance in standardised tests of English language proficiency such as IELTS. Page # ____.</i>
"Individual contextual factors, as signalled in the UCAS application, My Cambridge Application, and where applicable the Additional Applicant Information Form and/or Extenuating Circumstances Form;"	<ul style="list-style-type: none"> • <i>Appendix: Individual contextual factors. Page # ____.</i>
"Geo-demographic and school-level indicators such as those supplied by the Index of Multiple Deprivation and other UK databases (see here: https://www.undergraduate.study.cam.ac.uk/apply/after/contextual-data)."	<ul style="list-style-type: none"> • Appendix: Contextual data. Page # ____.

³ Generic statement that follows an individual student's feedback that they can (and always should) request after the application process has finished.



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Topic 9 Q# 91	116
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Topic 12 Q# 97	122
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Section 2 Topic 8 Q# 250	272
Section 2 Topic 9 Q# 257	280
Section 2 Topic 10 Q# 259	282
Section 2 Topic 11 Q# 261	284
Section 2 Topic 12 Q# 263	286
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Week Starting	Wk #	Events	Topic Focus
3-Jun	1	<p>Tue 4th PM Paper 1 (ADMINISTRATIVE Zone 5)</p> <p>When you have finished all of your exams, start planning out the rest of the year to know what you have to do and when:</p> <p>https://www.undergraduate.study.cam.ac.uk/apply</p> <p>https://www.ox.ac.uk/admissions/undergraduate/applying-to-oxford/guide</p>	
10-Jun	2	<p>Finish an early draft of Personal Statement and talk to someone, ideally a teacher or university counselor.</p> <p>Tell someone, probably several people, at your school you intend to apply to Oxford or Cambridge (ideally, they should know much earlier than this).</p> <p>Find out about the interview process and begin preparing (ideally earlier) by talking to others about science, ideally a teacher who knows about UCAS and Oxbridge applications.</p>	
17-Jun	3		
24-Jun	4	<p>Last chance usually to get feedback before the summer on your latest version of your personal statement</p>	
1-Jul	5		
8-Jul	6		
15-Jul	7		
22-Jul	8		
29-Jul	9	<p>Thursday 1st August – Start of ESAT registration period</p>	
5-Aug	10	<p>Thursday 15th August – Start of Oxford's BMSAT registration period</p>	
12-Aug	11		
19-Aug	12		
26-Aug	13	<p>Get your most up-to date version of your personal statement seen by someone at your school for feedback if possible; it should be largely finished now (for most students there will not be time to do anything extra to add to it now before the deadline)</p>	
2-Sep	14		
9-Sep	15	<p>Your personal statement should be ready to fit into the 4000-character 47-line limit; you should not be adding to it now, rather cutting out and condensing now</p>	

Week Starting	Wk #	Events	Topic Focus
16-Sep	16	Monday 16 th September – Deadline to register for the ESAT Cambridge Entrance Exam	
23-Sep	17		
30-Sep	18	Tue 1 st Morning Chemistry Paper 3.5 (ADMINISTRATIVE Zone 5) Last good opportunity to get feedback on your personal statement and then act on it 4 th October	
7-Oct	19		
14-Oct	20	TUESDAY 15TH OCTOBER UCAS DEADLINE for OXBRIDGE APPLICATIONS Tuesday 15 th ESAT Wednesday 16 th ESAT Fri 18 th Morning Chemistry Paper 2.3 & Paper 5.3 (ADMINISTRATIVE Zone 5)	
21-Oct	21		
28-Oct	22	Tue 29 th Morning Chemistry Paper 3.6 (ADMINISTRATIVE Zone 5)	
4-Nov	23	Interview invitations for Cambridge sent out this month starting about now Mon 4 th Morning Chemistry Paper 4.3 (ADMINISTRATIVE Zone 5)	
11-Nov	24	Thu 14 th Morning Chemistry Paper 1.3 (ADMINISTRATIVE Zone 5)	
18-Nov	25		
25-Nov	26		
2-Dec	27	Oxford interviews are carried out this week and next	
9-Dec	28		
16-Dec	29		
23-Dec	30		
30-Dec	31		
6-Jan	32		
13-Jan	33	Normally last Oxbridge interviews for Winter Pool applicants	

For calendars and revision timetables see “Appendix – Calendars and stage-management” at the back of this book



What is the ESAT?

Throughout this book direct quotes from indicated websites are used, with largely original formatting, **except passages highlighted yellow.**

"You need to take the Engineering and Science Admissions Test (ESAT) if you are applying for:

- Chemical Engineering and Biotechnology
- Engineering
- Natural Sciences
- Veterinary Medicine

You will take the test on 15 or 16 October 2024. You must take the test in this first sitting.

You should make sure to **register for the ESAT by 16 September 2024.**

Test format

The ESAT is a computer-based assessment. It is made up of individual multiple-choice assessments lasting 40 minutes each. You will sit these back-to-back on the day of the test.

Mathematics 1 is compulsory for all candidates.

The remaining assessments will depend on the Cambridge course you are applying to. If you're applying for Chemical Engineering and Biotechnology, Natural Sciences or Veterinary Medicine, you will complete Mathematics 1 and two additional multiple-choice assessments from the following list, making the test 120 minutes in total:

- Biology
- Chemistry
- Physics
- Mathematics 2

If you're applying for Engineering, alongside Mathematics 1, you'll also complete:

- Physics
- Mathematics 2

There is no pass or fail for ESAT. You should aim to do the best you can.

Your final scores are based on the number of correct answers you give. You do not lose marks for wrong answers, so it's worth attempting all questions.

How to register for the ESAT

You must be registered in advance to sit the ESAT.

You can [register for the ESAT](#) from 1 August 2024. The registration deadline is 16 September 2024.⁴

⁴ <https://www.undergraduate.study.cam.ac.uk/apply/how/science-engineering-admission-test> (accessed on 27th May 2024); www.SmashingScience.org



ESAT preparation recommendations

By far the most effective revision will be completing the past exam questions FOR THE FIRST TIME, starting from a position of strength, under timed conditions.

1. **Start early**, but not seriously until AFTER AS Paper 2 and 3 exams; could start this process before Paper 1 (usually end of May). **If you are finding AS or IB level difficult, DO NOT work on any of this until after ALL your May exams!**
2. Identify an ESAT/NSAA topic you are strong in and find the corresponding AS or IB topic at the back of this book. **NSAA questions are extremely rare** and should be done AFTER you are already extremely good at AS or IB questions NOT before!
3. Revise that topic using A level exam questions (and IB past exam questions, especially HL Paper 1 MCQ questions on relevant topics).
4. **Start with questions with explained answers** to them, which is indicated in the question ID that precedes each question.
5. When you are really confident in your understanding of that topic try **2 NSAA questions under timed conditions** (90 seconds per mark, 3 minutes).
6. **Mark** those 2 questions.
7. If you found them easy, and got them correct with time to spare, try another 2 questions of the same topic.
8. **If you found any question hard**, or couldn't finish in the time you had, **stop this process** and **use A Level** and IB exam questions to get stronger in this topic before you come back.
9. Some of the **last questions** you should try are **Section 2 MCQ** on ESAT syllabus topics (180 seconds per mark). These are available towards the back of this book. Start with the questions with explained answers to them.
10. The very last thing you could do, after you have gained full confidence in all aspects of the MCQ process, is the Section 2 short answer questions which are included at the very back, as well as the section 2 MCQ covering material that is not on the ESAT syllabus (essentially A2 or IB HL material). **More practice talking about biology** in preparation for the **interview** will be by far better use of time for nearly all students than solving these questions, however.
11. For students less familiar with AS or IB biology most of the work will be done using AS and IB exam questions to get to a suitable standard.
12. **If you arrive at this book later in the application process** (September for exams on the 15th October):
ignore AS or IB questions and just get as much of the MCQs in this book done as time allows.
13. **If you arrive at this book early** (September or October, the **YEAR BEFORE** you will sit the exam):
you can **try a small number** of these questions as you are studying AS biology after you have revised completely a given topic for a test or an exam but stop using this book if you are unable to get them correct within the time limit. For many students it would be better to do them after your AS exams, when their biology is stronger, rather than work unsuccessfully on them throughout the year. **You want to have had as much experience in delivering this skill of solving them for the first time, correctly, and as quickly as possible.** Being able to solve these kinds of question within the time limit, but only after several attempts is a skill that will not help much in the real exam.

Things to avoid:

- **Do NOT start after the summer holidays.**
- Do NOT only work over the summer holidays. Some time should be spent taking a real break that is able to recharge you so you can hit your September, October and November months with your full force. A break is doing something that you thoroughly enjoy doing, so if an activity could be put in a UCAS personal statement, it's highly unlikely to be properly regarded as a break.
- Spoiling the impact of a brand new and fresh NSAA past question, by for instance, looking over an NSAA question just to see what it looks like.
- Attempting any question in a given topic you are not sure you are really strong in (because of extensive work you have already done with AS or IB questions).

How the NSAA (1st exam 2016) became the ESAT (1st exam 2024)

No past exam papers exist for the ESAT, but the ESAT Preparation Materials⁵ suggested are all of the NSAA Section 1 exam papers.

The sample tests given on the official ESAT website⁶ all seem to be in line with Section 1:

- Same format: both MCQ with 5 to 8 possible answers
- Similar time: 90sec/mark for Section 1 and 89 sec/mark for the ESAT
- Identical syllabus, but Advanced Mathematics from Section 2 has been renamed and added to create Mathematics 2

NSAA changes: description

From 2016 to 2023 the Natural Science Admission Assessment, (NSAA)⁷ was a test⁸ all students sat when applying for any science subject at University of Cambridge. In its final form it was all Multiple-Choice Questions (MCQ), and had 2 exam papers, called Section 1 and Section 2.

Section 1 (always MCQ) has these parts:

- Part A Mathematics (compulsory)
- Part B Physics
- Part C Chemistry
- Part D Biology
- Part E Advanced Mathematics and Advanced Physics (until 2019, Part E was removed in 2020 and later)

Section 2 as a short answer exam (from 2016 to 2019) with these parts which are all optional, choose any 2:

- Physics P1 and P2 (contains Advanced Mathematics syllabi)
- Chemistry C1 and C2
- Biology B1 and B2

Section 2 as a MCQ short answer exam (from 2020 to 2023):

- Part X Physics
- Part Y Chemistry
- Part Z Biology

The **ESAT** has these parts:

- ESAT Mathematics 1 (syllabi almost identical to NSAA Mathematics in 2023) - Compulsory
- ESAT Biology (syllabi identical to NSAA Biology in 2023)
- ESAT Chemistry (syllabi identical to NSAA Chemistry in 2023)
- ESAT Physics (syllabi identical to NSAA Physics in 2023)
- ESAT Mathematics 2 (syllabi identical to NSAA Advanced Mathematics in 2023)

NSAA changes: analysis

The ESAT is essentially the NSAA Section 1 exam which also has Mathematics 1 (based on AS material) compulsory but these changes:

- 7 more MCQ questions (27 total) per Part
- 2 of the 4 optional Parts must be completed
- Mathematics 2 assesses material previously in NSAA Part X Physics from Section 2

⁵ <https://esat-tmua.ac.uk/esat-preparation-materials/>

⁶ <https://home.pearsonvue.com/uatuk>

⁷ <https://web.archive.org/web/20231207155418/https://www.undergraduate.study.cam.ac.uk/apply/how/natural-sciences-admission-test>

⁸ For past exam questions 20106 to 2022 including marking schemes, example answers and both Section 1 and Section 2 from Cambridge university: <https://www.undergraduate.study.cam.ac.uk/publications/natural-sciences-admissions-assessment-papers>



How the structure of the NSAA (Section 1 and 2) has changed through time:

Paper ID	Date	Day	Section	MCQ?	Total parts	Parts to do	Marks/ part	Total time	Total marks	Part A (Maths)	sec/ mark	Notes	Dictionaries or calculator allowed?
2016sp	Specimen	N/A	1	Yes	5	3	18	80	54	Essential	88.9		No
2016	2 nd Nov '16	Wed	1	Yes	5	3	18	80	54	Essential	88.9		No
2017	2 nd Nov '17	Thu	1	Yes	5	3	18	80	54	Essential	88.9		No
2018	31 st Oct '18	Wed	1	Yes	5	3	18	80	54	Essential	88.9		No
2019	30 th Oct '19	Wed	1	Yes	5	3	18	80	54	Essential	88.9		No
2020sp	Specimen	N/A			4	2	20	60	40	Essential	90	New format, advanced maths is gone	No
2020	November	N/A	1	Yes	4	2	20	60	40	Essential	90	No day	No
2021	November	N/A	1	Yes	4	2	20	60	40	Essential	90	No day	No
2022sp	Specimen											Section 1 not part of this, only Section 2	
2022	"2022"	N/A	1	Yes	4	2	20	60	40	Essential	90		No
2023	"2023"	N/A	1	Yes	4	2	20	60	40	Essential	90		No
2024	15/16 Oct '24	Tu/We	1	Yes	5	3	27	120	81	Essential	88.9	Section 1 (?) is now ESAT	No
2016sp	Specimen	N/A	2	No	6	2	25	40	50	N/A	48	6 multipart questions (range: 1 to 12 marks)	Name calculator model
2016	2 nd Nov '16	Wed	2	No	6	2	25	40	50	N/A	48	6 multipart questions (range: 1 to 12 marks)	Name calculator model
2017	2 nd Nov '17	Thu	2	No	6	2	20	40	40	N/A	60	6 multipart questions (range: 1 to 10 marks)	Name calculator model
2018	31 st Oct '18	Wed	2	No	6	2	20	40	40	N/A	60	6 multipart questions (range: 1 to 10 marks)	Name calculator model
2019	30 th Oct '19	Wed	2	No	6	2	20	40	40	N/A	60	6 multipart questions (range: 1 to 10 marks)	Name calculator model
2020sp	Specimen	N/A		Yes	3	1	10	30	10	N/A	180	"New format", half as many Qs as normal. All MCQ exam.	No calculator
2020	November	N/A	2	Yes	3	1	20	60	20	N/A	180		No calculator
2021	November	N/A	2	Yes	3	1	20	60	20	N/A	180		No calculator
2022sp	Specimen	N/A	2	Yes	3	1	10	30	10	N/A	180	"Updated for 2022", half as many Qs as normal. Cannot see what was updated, but explained answers were given	No calculator
2022	"2022"	N/A	2	Yes	3	1	20	60	20	N/A	180	Last one easily available	No calculator
2023	"2023"	N/A	2	?	?	?	?	?	?	N/A	180	Not published, but likely same format at 2022 and before	No calculator
2024												NSAA section 2 does not exist in 2024	

NSAT and ESAT syllabi comparisons

By looking with the aid of a plagiarism detector⁹, everything on the ESAT (on the left) is also on the NSAA 2023 syllabi (red highlight indicates exact match; **non-highlighted text is essentially what is not in the ESAT but was in the NSAA**). The difference is NSAA Section 2 material, which has been removed from the ESAT. Mathematics 2 in the ESAT is a renamed version of the NSAA Advanced Mathematics.

Back

Your File

Source: Batch Result

Uni Cambridge NSAA Specification_202...

May 29, 2024, 00:37:05

Mike Housden

Plagiarism Detection

98.1%

Content

Questions will draw upon the topics listed for each part in Appendix 1. All parts will assume knowledge of the content of Mathematics 1. The knowledge assumed for each part is summarised:

Part	Knowledge assumed
Mathematics 1	topics labelled 'M' in Appendix 1
Biology	topics labelled 'B', and topics labelled 'M', in Appendix 1
Chemistry	topics labelled 'C', and topics labelled 'M', in Appendix 1
Physics	topics labelled 'P', and topics labelled 'M', in Appendix 1
Mathematics 2	topics labelled 'M', and topics labelled 'MM', in Appendix 1

Candidates are expected to apply conceptual knowledge to solve problems. Some questions involve the straightforward application of this knowledge, but others require more creative thinking and the application of principles in less familiar contexts.

Scoring

In all parts, each correct answer will score 1 mark. No marks are deducted for incorrect answers. Results for each part will be reported separately.

Content

Section 1

Questions in Section 1 will draw upon the topics listed for each part in Appendix 1. All parts will assume knowledge of the mathematical content of Part A (Mathematics). The knowledge assumed for each part in Section 1 is summarised:

Part A (Mathematics)	Mathematics	(topics labelled 'M', Appendix 1)
Part B (Physics)	Physics Mathematics	(topics labelled 'P', Appendix 1) (topics labelled 'M', Appendix 1)
Part C (Chemistry)	Chemistry Mathematics	(topics labelled 'C', Appendix 1) (topics labelled 'M', Appendix 1)
Part D (Biology)	Biology Mathematics	(topics labelled 'B', Appendix 1) (topics labelled 'M', Appendix 1)

Section 2

Questions in Section 2 will draw upon the relevant subject-specific topics as in the following table:

Part X (Physics)	Advanced Physics Advanced Mathematics Physics Mathematics	(topics labelled 'AP', Appendix 2) (topics labelled 'AM', Appendix 2) (topics labelled 'P', Appendix 1) (topics labelled 'M', Appendix 1)
Part Y (Chemistry)	Advanced Chemistry Chemistry Mathematics	(topics labelled 'AC', Appendix 2) (topics labelled 'C', Appendix 1) (topics labelled 'M', Appendix 1)
Part Z (Biology)	Advanced Biology Biology Mathematics	(topics labelled 'AB', Appendix 2) (topics labelled 'B', Appendix 1) (topics labelled 'M', Appendix 1)

All parts in this section assume knowledge of the mathematical content of Section 1 Part A (Mathematics). Parts X (Physics), Part Y (Chemistry) and Part Z (Biology) assume knowledge of the specified additional 'Advanced' content listed in Appendix 2.

Candidates are expected to apply conceptual knowledge to deconstruct and solve problems. Some questions involve the straightforward application of this knowledge, but others require more creative thinking, problem solving, and the application of principles in less familiar contexts.

Scoring

In both Section 1 and Section 2, each correct answer will score 1 mark. No marks are deducted for incorrect answers. Results for each part will be reported separately.

APPENDIX 2: ADDITIONAL ASSUMED KNOWLEDGE IN SECTION 2

The material that follows outlines the additional scientific and mathematical knowledge assessed in Section 2 of the Natural Sciences Admissions Assessment.

Section 2 consists of three parts. Candidates will be required to answer one part only. The three parts are:

- Part X: Physics
- Part Y: Chemistry
- Part Z: Biology

There are 20 multiple-choice questions in each part.

The time allowed to complete Section 2 is 60 minutes.

Calculators may NOT be used in Section 2.

Questions in Section 2 will draw upon the relevant subject-specific topics as in the following table:

Part X (Physics)	Advanced Physics Advanced Mathematics Physics Mathematics	(topics labelled 'AP', Appendix 2) (topics labelled 'AM', Appendix 2) (topics labelled 'P', Appendix 1) (topics labelled 'M', Appendix 1)
Part Y (Chemistry)	Advanced Chemistry Chemistry Mathematics	(topics labelled 'AC', Appendix 2) (topics labelled 'C', Appendix 1) (topics labelled 'M', Appendix 1)
Part Z (Biology)	Advanced Biology Biology Mathematics	(topics labelled 'AB', Appendix 2) (topics labelled 'B', Appendix 1) (topics labelled 'M', Appendix 1)

All parts assume knowledge of the mathematical content of Section 1 Part A (Mathematics).

Parts X (Physics), Part Y (Chemistry) and Part Z (Biology) assume knowledge of the specified additional 'Advanced' content listed in Appendix 2.

ADVANCED CHEMISTRY

AC1. Atomic structure

- AC1.1 Deduce the electron configuration of atoms (up to Z = 36) and corresponding ions (given ions change in terms of main energy levels and s, p and d orbitals).
- AC1.2 Define first ionisation energy, and write equations for first and successive ionisation energies.
- AC1.3 Understand how first and successive ionisation energies in Period 3 and Group 2 relate to electron shells and subshells.
- AC1.4 Understand how a simple time-of-flight (ToF) mass spectrometer works, including expressions for kinetic energy ($\frac{1}{2}mv^2$) and speed ($\frac{d}{t}$).

AC2. Bonding and structure

- AC2.1 Describe permanent and induced dipole-dipole interactions between molecules, including hydrogen bonding.
- AC2.2 Describe the term electronegativity, and use it to explain the existence of polar bonds.
- AC2.3 Know why some molecules with polar bonds do not have a permanent dipole.
- AC2.4 Understand and be able to predict the shapes of simple molecules and ions with up to six outer shell pairs of electrons (any combination of bonding pairs and lone pairs, excluding those involving a total of 5 pairs with at least one lone pair) in terms of electron pair repulsion theory (VSEPR).

ADVANCED BIOLOGY

AB1. Cell structure








- AB1.1 Know and understand the principles and limitations of light microscopes, transmission electron microscopes and scanning electron microscopes, including reference to magnification and resolution.
- AB1.2 Recall and apply the equation: $\text{magnification} = \frac{\text{image size}}{\text{actual object size}}$
- AB1.3 Know and understand the structure and function of the main organelles and cellular components found in eukaryotic cells including:
 - a. nucleus
 - b. nucleus (including nuclear envelope)
 - c. rough endoplasmic reticulum (RER)
 - d. smooth endoplasmic reticulum (SER)
 - e. ribosome
 - f. Golgi apparatus
 - g. lysosome
 - h. tonoplast
 - i. vacuole
 - j. centrioles

ADVANCED PHYSICS

AP1. Forces and equilibrium

- AP1.1 Understand the nature of scalars and vectors:
 - a. Examples include velocity, speed, mass, momentum, force, weight, acceleration, displacement and distance.
 - b. Know and be able to interpret vector notation.
- AP1.2 Components and results of vectors:
 - a. Be able to resolve a vector into two components at right angles to each other by drawing and by calculation.
 - b. Be able to calculate the moment of a force about a point (2 dimensions only).
 - c. Find the resultant of two coplanar vectors at right angles to each other by calculation.
- AP1.3 Moments:
 - a. Understand moment defined as force \times perpendicular distance from the point to the line of action of the force.
 - b. Be able to calculate the moment of a force about a point (2 dimensions only).
 - c. Know and be able to apply the principle of moments.

MATHEMATICS 1

HS-12.1 Calculate fluently with fractions, decimals and multiples of 10.
Simplify and evaluate moving across, e.g. $\sqrt{12} = 2\sqrt{3}$       

$$\frac{3}{\sqrt{7}} = \frac{3}{1} \cdot \frac{2}{2} = \frac{6}{2\sqrt{7}} = \frac{3}{\sqrt{7}}$$

HS-12.2 Calculate with square and square roots, and use in contextual problems.

HS-12.3 Round numbers and measures to an appropriate degree of accuracy, e.g. 1 is a useful number of decimal places for significant figures.

HS-12.4 Use approximation to produce estimates of calculations, including expressions involving π (square).

[illegible]

CHEMISTRY

[illegible][illegible]

MATHEMATICS

[illegible]

M2.1: Calculate exactly with fractions, surds and multiples of π .
Simplify surd expressions involving squares, e.g. $\sqrt{12} = \sqrt{4 \times 3} = \sqrt{4} \sqrt{3} = 2\sqrt{3}$.
Warning: denominators for algebraic fractions should be added to rationalise.
Expressions such as: $\frac{1}{\sqrt{2}} = \frac{1}{\sqrt{2}} \times \frac{\sqrt{2}}{\sqrt{2}} = \frac{\sqrt{2}}{2}$.

M2.2: Calculate with upper and lower bounds, and work to some decimal accuracy.

M2.3: Round numbers and measured to an appropriate degree of accuracy; write in scientific number of decimal places or significant figures.

[illegible]

CHEMISTRY

CA Atomic structure:

- 1.1 Explain the structure of atoms as a central nucleus of protons and neutrons surrounded by electrons moving in discrete energy levels
- 1.2 Explain the relative masses and charges of subatomic particles: electrons and protons
- 1.3 Explain the relative masses and charges of subatomic particles: neutrons and protons
- 1.4 Explain the relative masses and charges of subatomic particles: neutrons and protons
- 1.5 Explain the relative masses and charges of subatomic particles: neutrons and protons
- 1.6 Explain the relative masses and charges of subatomic particles: neutrons and protons
- 1.7 Explain the relative masses and charges of subatomic particles: neutrons and protons
- 1.8 Explain the relative masses and charges of subatomic particles: neutrons and protons
- 1.9 Explain the relative masses and charges of subatomic particles: neutrons and protons
- 1.10 Explain the relative masses and charges of subatomic particles: neutrons and protons

CA The Periodic Table (IUPAC conventions, Groups and labelled sections)

- 2.1 Explain the periodic table as a table of elements arranged in order of increasing atomic number
- 2.2 Explain the periodic table as a table of elements arranged in order of increasing atomic number
- 2.3 Explain the periodic table as a table of elements arranged in order of increasing atomic number
- 2.4 Explain the periodic table as a table of elements arranged in order of increasing atomic number
- 2.5 Explain the periodic table as a table of elements arranged in order of increasing atomic number
- 2.6 Explain the periodic table as a table of elements arranged in order of increasing atomic number
- 2.7 Explain the periodic table as a table of elements arranged in order of increasing atomic number
- 2.8 Explain the periodic table as a table of elements arranged in order of increasing atomic number
- 2.9 Explain the periodic table as a table of elements arranged in order of increasing atomic number
- 2.10 Explain the periodic table as a table of elements arranged in order of increasing atomic number

CA Chemical reactions, formulas and equations

- 3.1 Explain that atoms in a chemical reaction: their numbers are conserved
- 3.2 Explain that atoms in a chemical reaction: their numbers are conserved
- 3.3 Explain that atoms in a chemical reaction: their numbers are conserved
- 3.4 Explain that atoms in a chemical reaction: their numbers are conserved
- 3.5 Explain that atoms in a chemical reaction: their numbers are conserved
- 3.6 Explain that atoms in a chemical reaction: their numbers are conserved
- 3.7 Explain that atoms in a chemical reaction: their numbers are conserved
- 3.8 Explain that atoms in a chemical reaction: their numbers are conserved
- 3.9 Explain that atoms in a chemical reaction: their numbers are conserved
- 3.10 Explain that atoms in a chemical reaction: their numbers are conserved

BIOLOGY

01: Cells

01.01: Know and understand the structure and function of the main sub-cellular components (eukaryotic cells: plant, animal and prokaryotic)

- 01.01.01 Mitochondria
- 01.01.02 Cytoplasm
- 01.01.03 Nucleus
- 01.01.04 Endoplasmic reticulum
- 01.01.05 Golgi apparatus
- 01.01.06 Lysosomes
- 01.01.07 Chloroplasts (plant only)
- 01.01.08 Cell wall (plant only)

01.02: Know and understand the structure and function of the main sub-cellular components (prokaryotic cells: bacterial including)

- 01.02.01 The cell wall
- 01.02.02 Cytoplasm
- 01.02.03 Ribosomes
- 01.02.04 Circular DNA (bacterial)
- 01.02.05 Plasmids (DNA)

01.03: Know and understand the levels of organisation within organisms (all: cells to tissues, organs to organ systems)

02: Movement across membranes

02.01: Know and understand the processes of diffusion, osmosis (in terms of water potential) and active transport (including examples in living and non-living systems)

03: Cell division and sex determination

03.01: Meiosis and the cell cycle

- 03.01.01 Know and understand that the process of cell cycle involves mitosis and cytokinesis

1. Know and understand the importance of mitosis in the growth of an organism

[illegible]

MATHEMATICS 2

MM1: Algebra and functions:

MM1.1: Laws of indices for real and rational exponents

MM1.2: Use and manipulation of surds

MM1.3: Factorising expressions using algebraic identities, including the difference of two squares

For example, simplifying: $\frac{2x^2 + 5x - 3}{2x^2 - 5x + 3}$ $\frac{(2x-1)(x+3)}{(2x-3)(x+1)}$

MM1.4: Quadratic functions and their graphs; the discriminant of a quadratic function; the nature of the roots of a quadratic equation

MM1.5: Simultaneous equations: algebraic solution by substitution; e.g. of one linear and one quadratic equation

MM1.6: Solution of linear and quadratic inequalities

MM1.7: Algebraic manipulation of polynomials, including:

- a) ascending/bi-quadratic and collecting like terms
- b) factorisation and known algebraic division by a linear polynomial, the roots of the form $ax^2 + bx + c = 0$ and $ax^3 + bx^2 + cx + d = 0$ (where $a \neq 0$)
- c) use of the Factor Theorem and the Remainder Theorem

MM1.8: Quadratic understanding that a function is a mapping from one set (domain) to another (co-domain)

Familiarity with the properties of common functions, including $y = f(x)$ and $y = f^{-1}(x)$ forms the positive square root and $\sqrt[3]{x}$ and $\sqrt[n]{x}$

MM2: Sequences and series

MM2.1: Sequences: determining those given by a formula for the n th term and those given an explicit recursive relation of the form $u_n = f(n, u_{n-1})$

MM2.2: Arithmetic series: identifying the formulae for the sum of the first n natural numbers

MM2.3: The sum of finite geometric series

MM2.4: The sum of infinite geometric series; the sum of infinite geometric series, including the series $1 + x + x^2 + \dots$ and $1 - x + x^2 - \dots$ and their applications; and the expansions of $\frac{1}{1+x}$ and $\frac{1}{1-x}$ for small values of x and series of x^n

BIOLOGY

BI1 Cells

Q1.1 Choose and understand the structure and function of the main sub-cellular components of eukaryotic cells (such as animal and plant) including:

- ☐ ☐ 1. Nucleolus
- ☐ ☐ 2. Nucleus
- ☐ ☐ 3. Cytoplasm
- ☐ ☐ 4. Mitochondrion
- ☐ ☐ 5. Golgi apparatus
- ☐ ☐ 6. Lysosome
- ☐ ☐ 7. Peroxisome
- ☐ ☐ 8. Vacuole
- ☐ ☐ 9. Centrioles
- ☐ ☐ 10. Chloroplast

Q1.2 Choose and understand the structure and function of the main sub-cellular components of prokaryotic cells (bacteria and archaea):

- ☐ ☐ 1. Nucleolus
- ☐ ☐ 2. Nucleus
- ☐ ☐ 3. Cytoplasm
- ☐ ☐ 4. Mitochondrion
- ☐ ☐ 5. Golgi apparatus
- ☐ ☐ 6. Lysosome
- ☐ ☐ 7. Peroxisome
- ☐ ☐ 8. Vacuole
- ☐ ☐ 9. Centrioles
- ☐ ☐ 10. Chloroplast

Q1.3 Choose and understand the levels of organisation within organisms and cells to illustrate the scope to organ systems:

I

Q2. Movement across membranes

Q2.1 Choose and understand the processes of diffusion, osmosis (in terms of water potential) and active transport, including applications to living and non-living systems:

I

Q3. Cell division and new determination

Q3.1 Choose and the cell cycle:

[illegible]

ADVANCED MATHEMATICS

AM1: Algebra and Functions

AM1.1: Levels of indices for all relevant operations

AM1.2: Use and manipulation of surds

Identifying expressions that contain surds, including rationalising the denominators

For example: simplify $\sqrt{8} - \sqrt{2}$ and $\sqrt{2} + \sqrt{2}$

AM1.3: Quadratic functions and their graphs; the discriminant of a quadratic function; completing the square; solutions of quadratic equations

AM1.4: Solving quadratic equations (graphically) by substitution, in a set of one linear and one quadratic equation

AM1.5: Solution of linear and quadratic inequalities

AM1.6: Exponential relationships of functions, including:

- Recognising, representing and collecting like terms
- Recognising and simplifying algebraic forms (such as linear polynomial, including those of the form $ax + b$ and $ax^2 + bx + c$)
- Recognising and simplifying algebraic forms (such as quadratic polynomial, including those of the form $ax^2 + bx + c$)
- Using the laws of Indices, Transforms and the Binomial Theorem

AM1.7: Graphical understanding that a function is a many-to-one relationship (just a sketch)

Familiarity with the properties of common functions, including $f(x) = 2^x$ (which always shows the double square root and $f(x) = \log_2(x)$)

AM2: Sequences and series

AM2.1: Sequences, including those given by a formula for the n^{th} term and those generated by simple recursive relationships

AM2.2: Arithmetic series, including the formulae for the sum of the first n terms of such series

AM2.3: The sum of a finite geometric series

The sum to infinity of a convergent geometric series; the value of $\sum_{n=0}^{\infty} x^n$ for $|x| < 1$

AM2.4: The binomial expansion of $(a + x)^n$ for any real n ; and for expressions of the form $(a + x)^n(1 + x)^m$ for positive integer n and any real m

The binomial coefficient $\binom{n}{r}$

negative value of a as represented by:

- a. $y = af(x)$
- b. $y = f(x) + a$
- c. $y = f(x - a)$
- d. $y = f(ax)$

MM8.3 Understand how altering the values of

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Additional information

IB Biology Higher Level Paper 1 multiple choice questions can be helpful here, IB Questionbank is a program that can help you find these questions in a given IB topic.

There is a note about when marking would happen for the 2016 exam for Biology, at 11th November, the exam was on the 2nd November, which implies that the marking of them happens as one might expect, and before the interviews.

The exam will be online: your practice of these questions should reflect the actual conditions. Instead of annotating the questions, which is normally on a paper exam the best way to process and present your thinking, learn how to write these notes in an effective way on scrap lined paper. This skill can be built with AS MCQ questions, but it is unlikely to add value to AS exam technique, so only invest time and energy after your AS Paper 1, or after you have achieved a level of performance where you almost never drop a mark under timed conditions for that topic.

A note on how marks were assigned topics

Sometimes topic boundaries are blurred.

Remember, these questions need to be done without a calculator, and if there are about 3 steps to an IB HL question, there are 5 to 7 steps for a calculation question in the NSAA/ESAT. A single mistake at any step will result in the mark, and the time invested, being lost. So being quick and but especially error free for these kind of questions is key.

I

Explained Exam Mark Schemes for MCQs

The Specimen Paper for 2020 has explained answers for section 1 questions.

The Specimen Paper for 2022 has explained answers for section 2 questions.

Comments on marking and unusual questions

Sometimes in section 2 chemistry questions 2 marks was assigned for a single point, or 4 marks were assigned for a single correct number, but the method marks were not clearly described. This implies a style and a creative flair in the marking process that would be hard to find in CAIE or IB mark schemes for such a small sample space. This is for the older short answer section 2 before it became all multiple choice, so a lot less relevant moving ahead, but it can be helpful to think that these kinds of questions do not follow all of the same principles and processes as, for instance CAIE A Level or IB Diploma Level. Other parts of other assessment points, like the interview, might also be importantly different.

Alternative universities: Using effective planning to make difficult things less stressful

A good applicant to Oxbridge has already had a magnificent amount of success in school and will continue to be successful with continued hard work, regardless of which university they eventually study at. You should be aiming to deliver your best performance, in a positive and productive way. You can definitely push yourself and find out how to get the most from yourself, not just sometimes, but for weeks and months at a time, all towards a really long term, but important life goal.

You should be aware that you'll be using your brain throughout, in the same way that an athlete will use their body, so you need to work in a way that maximises its performance. Stress, negativity and bad vibes aren't just totally uncool, they also do not make a brain more open to remembering or processing new ideas, or more able to deliver the higher order thinking skills which are exactly what this process done well will deliver. In fact, the brain is designed to protect you if it feels too stressed, and it does that through a variety of emotional feedback loops, like the fight or flight response, which sets the stage for how you perceive new things, lowers your levels of intellectual interest and reduces your ability to deliver thought-based work, like learning, under pressure. In the brain's evolutionary history, individuals that ran away from stressful situations, like a large predator, more often survived and reproduced than others that took the time to explore their fascination with the magnificent predator eating their slower moving friend. So, you should be aiming to reduce or eliminate as much unnecessary stress and anxiety as possible to maximise your brain's processing power, and your ability to push yourself towards splendid success.

Common to how brains work is to reduce a situation to a binary outcome, in this case, pass or fail, Oxbridge or nothing. But that is not at all true. If you plan to for another top university as a backup you can really help your brain function better, and by doing this actually improve your performance, and therefore improve your chances. You can still ask of yourself more work than you see others doing, more often, and to find a way, through deliberate and thoughtful action to be more interested than even the strongest students in your year group. You are at the start of a long journey, so it can seem that these first few steps are exceptionally important, but years of hard work later on will be far more important to your life's biggest successes.



UCAS entry requirements for some degrees that need Chemistry A Level (as of Nov. 2023)

For your best performance you should think of this process as part of the most important year in education, how ambitious you are, and how hard you work, and how much you grow will set a range of limits and expectations for years to come, but you are aiming to move from excellent to outstanding, and

Uni	Biochemistry Degree			Biology Degree			Pharmacy Degree			Medicine			GCSE requirements		
	BSc or MSci	A Level	IB	A Level	IB	Bio Notes	A Level	IB	Notes	A Level	IB	Notes	Math	English	Other
Aberystwyth	BSc	BBC/BBB	28/30	BCC/BBB	28/30	Biology							N/A	4/C	C in Biology
Aston	BSc	BBB		BBB	31	Biological sciences	BBB/ABB	31/32		A*AA	39	UCAT and Interview needed	4/C	4/C	
Bath	MBiochem	AAB	36	AAB	36	Biology	AAB	36	¹⁰				4/C	4/C	
Bath	BSc	AAB	36	AAB	36	Biology			¹¹				4/C	4/C	
Birmingham	BSc	AAB	32	AAB	32	Biological sciences				A*AA	32		N/A	N/A	5xC
Birmingham	MSci	AAA	32 (HL 665)	AAA	32	Biological sciences	AAB	32							
Birmingham	BSc ¹²	AAB	32												
Bristol	MSci	ABB/AAA	32-36	ABB/AAA	32-36	Biology				BBC	29	¹³			
Bristol	BSc	ABB/AAA	32-36	ABB/AAA	32-36	Biology				ABB/AAA	32/36	Standard entry, UCAT			
Cambridge				A*A*A	40/42					A*A*A	40/42	BMAT			
Durham	BSc	AAA	37	N/A		Biological sciences							N/A	N/A	
East Anglia	BSc	ABB	32	ABB	32	Biological sciences							4/C	4/C	
East Anglia	MSci	AAB		AAB	33	Biological sciences	AAB	33		AAA	36	UCAT and Interview needed			
Edinburgh	BSc	ABB/AAA	32/37	ABB/AAA	32/37	Biological sciences				A*AA	40				
Glasgow	BSc	BBB/AAB	32/36												

¹⁰ MPharm & Always interviewed

¹¹ <https://www.pharmacyschoolscouncil.ac.uk/study/international-applicants/>

¹² Medical Biochem

¹³ Gateway to medicine, UCAT. This course is open to applicants from specific schools and colleges in the UK only and/or to those who have spent 3 months or more in care. Further information and lists of the eligible schools and colleges is available at contextual offers: <http://www.bristol.ac.uk/study/undergraduate/entry-requirements-qualifications/contextual-offers/>

Uni	Biochemistry Degree			Biology Degree			Pharmacy Degree			Medicine			GCSE requirements		
	BSc or MSci	A Level	IB	A Level	IB	Bio Notes	A Level	IB	Notes	A Level	IB	Notes	Math	English	Other
Greenwich	BSc			32 points from Bio	HL5	Biology									
Huddersfield	BSc	BCC/BBC	112-104 points ¹⁴	BCC/BBC	112-104 points	Biological sciences	BBB/ABB	136 UCAS points ¹⁵	-	-	-	-			
Imperial	BSc	AAA	38	AAA	38	Biological sciences				AAA	38	BMAT			
Imperial	MSci	AAA	38												
King's, KCL	BSc	AAA	35	N/A			AAB	35		A*AA	35				
Kingston	BSc	BBC/ABB	27	BBC/ABB	27	Biological sciences	BBB/AAB	32							
Liverpool	BSc	ABB	33	ABB	33	Biological sciences				AAA/A*AB		¹⁶	4/C		
Manchester	BSc	AAB/AAA	35/36	AAB/AAA	35/36	Biology	AAB	35		AAA	36	UCAT and Interview needed	4/C	4/C	
Nottingham	BSc	AAB	34	AAB	34	Biology	AAB	34					6/B	4/C	
Nottingham		AAB	34										6/B	4/C	
Oxford	MBio	A*AA	39	A*AA	39	Biology									
Queen Mary	BSc	ABB	34	ABB	34	Biology				A*AA	38	UCAT and Interview needed	4/C	4/C	
Queen's University Belfast	BSc	BBB/ABB	32/33	BBB/ABB	32/33	Biological sciences	AAB	34		A*AA	Not given	UCAT and Interview needed	C	C	CC in Double science
Royal Holloway, Uni London	BSc	BBC/BBB	32	N/A											5x A* to C
UCL	BSc	AAA	38	AAA	38	Biological sciences	AAB	36					6/B	6/B	
Warwick	BSc	ABB/AAB	32-34	ABB/AAB	32-34	Biological sciences									
York	BSc	AAB	35	AAB	35	Biology									

¹⁴ UCAS tariff points from International Baccalaureate qualifications which should include modules in relevant Science subjects.

¹⁵ including Higher Level Chemistry at grade 6 and Higher Level Mathematics and Biology at grade 6 and 5 (in any order).

¹⁶ A levels taken in one sitting after a 2 year period of study, AAA, to include Chemistry together with either Biology, Physics or Mathematics and a third academic subject. The Advanced Welsh Baccalaureate Skills Challenge Certificate is accepted in lieu of a third academic subject. Alternatively, A*AB also accepted but the A* A grades must include Chemistry together with either Biology, Physics or Maths; and a B grade required in the third academic subject. Applicants with a minimum of 12 points at GCSE may be considered if, at the time of application, they have achieved AAA or A*AB (as defined above). GCSEs in nine subjects attained by the end of Year 11 which must include: English Language, Mathematics, Biology, Chemistry, and Physics. Core & Additional Science is an acceptable alternative to the three individual sciences. Minimum of grade B (score 6) required in core subjects



Selected Chemistry degrees and entrance requirements

University	Chemistry Degree		Material Science Degree		Chemical Engineering		Deadline
	A Levels	IB points	A Levels	IB points	A Levels	IB points	
Aberystwyth							31-Jan
Aston	BCC/BBC				BCC/BBB	31	31-Jan
Bath	AAB/AAA	36					31-Jan
Bath					A*AA	36	31-Jan
Birmingham	AAB/AAA	32	AAB	32	AAA	32 (HL 666)	31-Jan
Birmingham	AAA/AAA*				A*AA/AAAA ¹⁷	32	31-Jan
Birmingham							31-Jan
Bristol					N/A		31-Jan
Bristol	ABB/AAA	32-36			N/A		31-Jan
Cambridge	A*A*A	40/42			A*A*A	40/42	16-Oct
Durham	A*AA	38					31-Jan
East Anglia	BBB	31					31-Jan
East Anglia	AAB	33					31-Jan
Edinburgh	ABB/AAA	32/37			ABB/AAA	32/37	31-Jan
Glasgow							
Greenwich	32 points from Chemistry	HL5			¹⁸	HL5 Maths and Phx	31-Jan
Huddersfield	BCC/BBC	112-104 points			BBC/BBB ¹⁹	Not given	31-Jan
Imperial	AAA	38	AAA	38	A*A*A	40	31-Jan
Imperial							31-Jan
King's, KCL	AAA	35					31-Jan
Kingston	BBC/ABB	28					31-Jan
Liverpool	ABB	33					31-Jan
Manchester	AAA ²⁰	36	AAB	35	AAA ²¹	36	31-Jan
Nottingham	ABB/AAB ²²	32-34			AAA	36	31-Jan
Nottingham							31-Jan
Oxford ²³	A*A*A	40	A*AA	40	A*A*A	40	16-Oct
Queen Mary	ABB	34	ABB	32	AAB	34	31-Jan
Queen's University Belfast	BBB ²⁴	32			BBB	32	31-Jan
Royal Holloway, Uni London	N/A						31-Jan
UCL	AAA	38			AAA	38	31-Jan
Warwick	AAB	34					31-Jan
York	AAB/A*AA	35/37					31-Jan

¹⁷ Only course to ask for 4 Alevels!

¹⁸ 32 points from Chemi32 Points from Mathematics and 32 points from a physical science or a numerate subject.

¹⁹ <https://www.hud.ac.uk/undergraduate/how-to-apply/entry-requirements/>

²⁰ English is easier 6.5 overall with no less than 6.0 in any component

²¹ AAA including Mathematics and either Chemistry or Physics.

²² Need a C in maths GCSE, easier

²³ MChem only available, no BSc offered

²⁴ Only need C in GCSE maths

Factors that affect acceptance rates for Cambridge

What does success in the ESAT look like?

Key information supplied by the University of Cambridge regarding the ESAT and especially the NSAA over the last few years:

"Please note that your performance in the pre-interview assessment will not be considered in isolation, but will be taken into account alongside the other elements of your application.

Specimen and past papers

A specimen paper has been produced to allow you to sample the written assessment format and practice under timed conditions. It is not expected that you will answer every question correctly; the written assessment is designed to be challenging. **Even some strong candidates may not complete the paper in the time allowed**; it is designed to distinguish across our field of high-calibre applicants.

Experience with similar assessments and from trials indicates that, on average, typical applicants to the most highly selective undergraduate courses (who are by definition academically very able) **will gain approximately half of the available marks**. The best applicants will score more highly, but only **relatively few are expected to gain more than 80 per cent** of the available marks.

Written assessments help admissions tutors to assess whether candidates have the skills, aptitudes and any required subject knowledge and understanding required to study the relevant course at Cambridge. They are only one of the elements used in the admissions process. Others include:²⁵

1. a candidate's academic record and forecast grades in school-leaving examinations;
2. UCAS application form;
3. examples of recent written work submitted to the College to which they are applying;
4. and performance at interview, if invited to attend.(2020)"²⁶

"You don't need to get every question right

We don't expect that you will answer every question correctly. The assessments are designed to challenge you.

Some strong applicants may not even complete the paper in the time given. Almost no one gets full marks.(2024)"²⁷

For more details on changes to this website see "*Appendix – Changes to the Natural Sciences Entrance Requirements webpage through time*" at the back of this book.

In addition to the websites, Cambridge also delivers information through feedback on individual applicants (this was used in the section at the start of this book: *Contents mapped to Cambridge's assessment of applicants list*.

"Our assessment includes, in **no particular order**:

1. Recent academic achievement, as evidenced by transcripts, GCSEs (or equivalent), AS-levels (where relevant), A-levels, or other school-leaving qualifications;
2. Contents of references and quality of predicted grades, where relevant;
3. Quality of the personal statement, and evidence of interest in the subject to be studied and of engagement with that subject outside the classroom;

4. Performance in admissions assessments, where relevant;

5. Quality of submitted work, where relevant;
6. Performance at interview;
7. Performance in standardised tests of English language proficiency such as IELTS, where relevant;
8. Individual contextual factors, as signalled in the UCAS application, My Cambridge Application, and where applicable the Additional Applicant Information Form and/or Extenuating Circumstances Form;
9. Geo-demographic and school-level indicators such as those supplied by the Index of Multiple Deprivation and other UK databases (see here:
<https://www.undergraduate.study.cam.ac.uk/apply/after/contextual-data>)."²⁸

In this list they have also included references. And while they have explicitly stated that these are not in order, it does seem that there is in fact a particular order, or hierarchy, to their assessment process, and that some things are more important than others, which can be seen later where we see some students who have top NSAA scores can also be rejected.

²⁵ The original paragraph has been reformatted here to convert this sentence into a numbered list

²⁶ From: <https://www.undergraduate.study.cam.ac.uk/courses/natural-sciences#entry-requirements> (accessed September 2020)

²⁷ <https://www.undergraduate.study.cam.ac.uk/apply/how/admission-tests>, accessed 27th May 2024

²⁸ Generic statement that follows an individual student's feedback that they can (and always should) request after the application process has finished. [The original bullet points were changed to the numbered list]



UMS performance and the eventual HE destination of Cambridge applicants

The emphasis placed on attainment at AS-level in the Cambridge admissions process makes it very probable that those applicants who are successful in obtaining an offer of a place at the University have a stronger academic record than those who are unsuccessful. While it is difficult to capture in statistics the full assessment made of an applicant's academic record, a proxy through which to operationalise relative attainment is through the use of UMS.

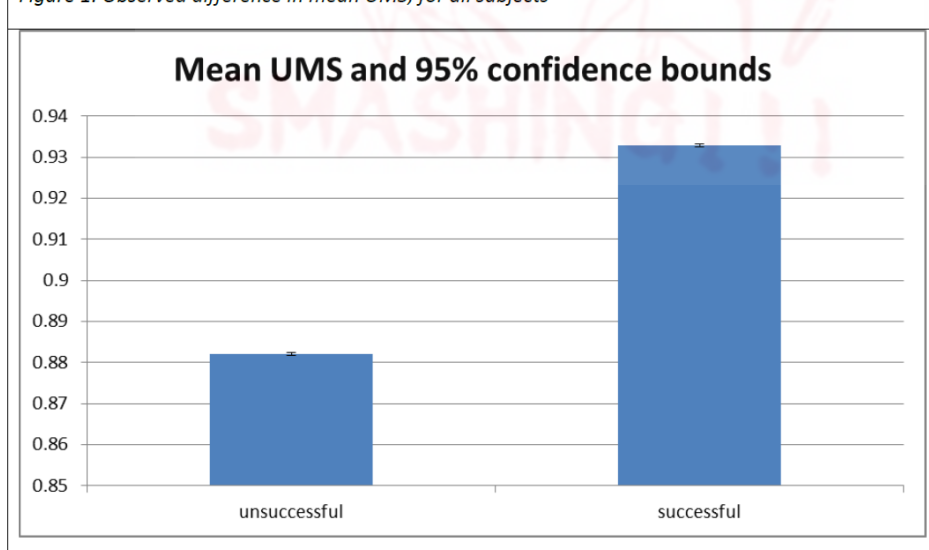
This short paper therefore tests the hypotheses that:

- The UMS attainment of applicants made an offer of a place at Cambridge is significantly higher than those not made the offer of a place, and,
- That this relationship is consistent across all Tripos subjects for which students are admitted, and,
- That differentiation in UMS attainment is consistent across the sector, in that the Cambridge applicants with the highest attainment tend to attend the more selective universities.

This is a report by into students UMS (Uniform Mark Scale, the UK version of PUM, Percentage Uniform Mark score, which is used in international exams like the ones used by CAIE) from their AS levels, which were achieved before they applied to university. The main finding was that the students accepted into the university had on average a UMS score of 93 across all of their subjects, while those rejected had a UMS score of 88. The fact that this study of 40 000 applicants was carried out, and especially because it was published and is still hosted by the university means that this is something they would like the world, and probably also prospective applicants, to know about. They are the only university that asks every student specifically for their UMS/PUM scores.

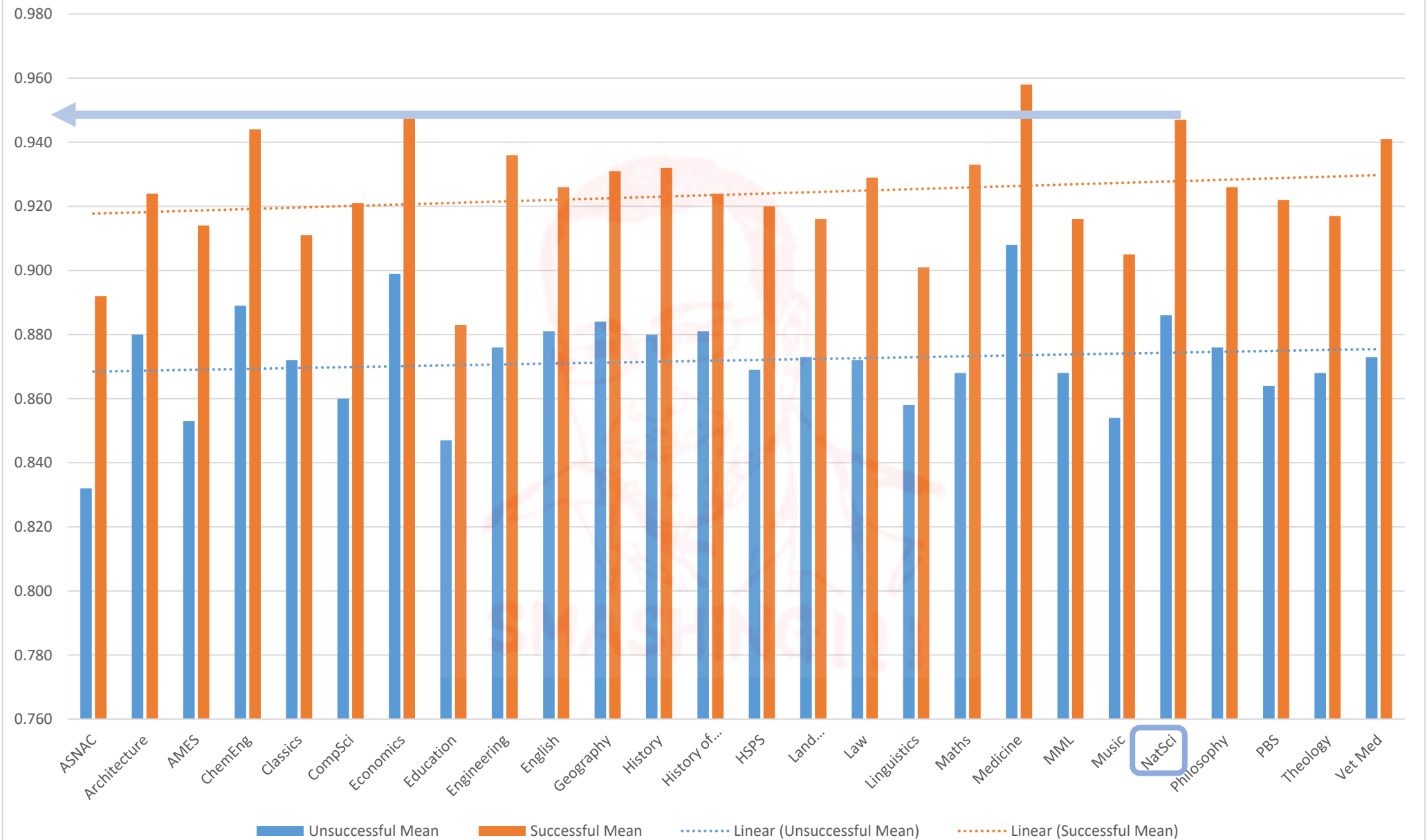
Another way to think about this is that if you have a lower UMS/PUM score, you probably might rethink Cambridge, and maybe lean more towards Oxford instead.

Figure 1. Observed difference in mean UMS, for all subjects

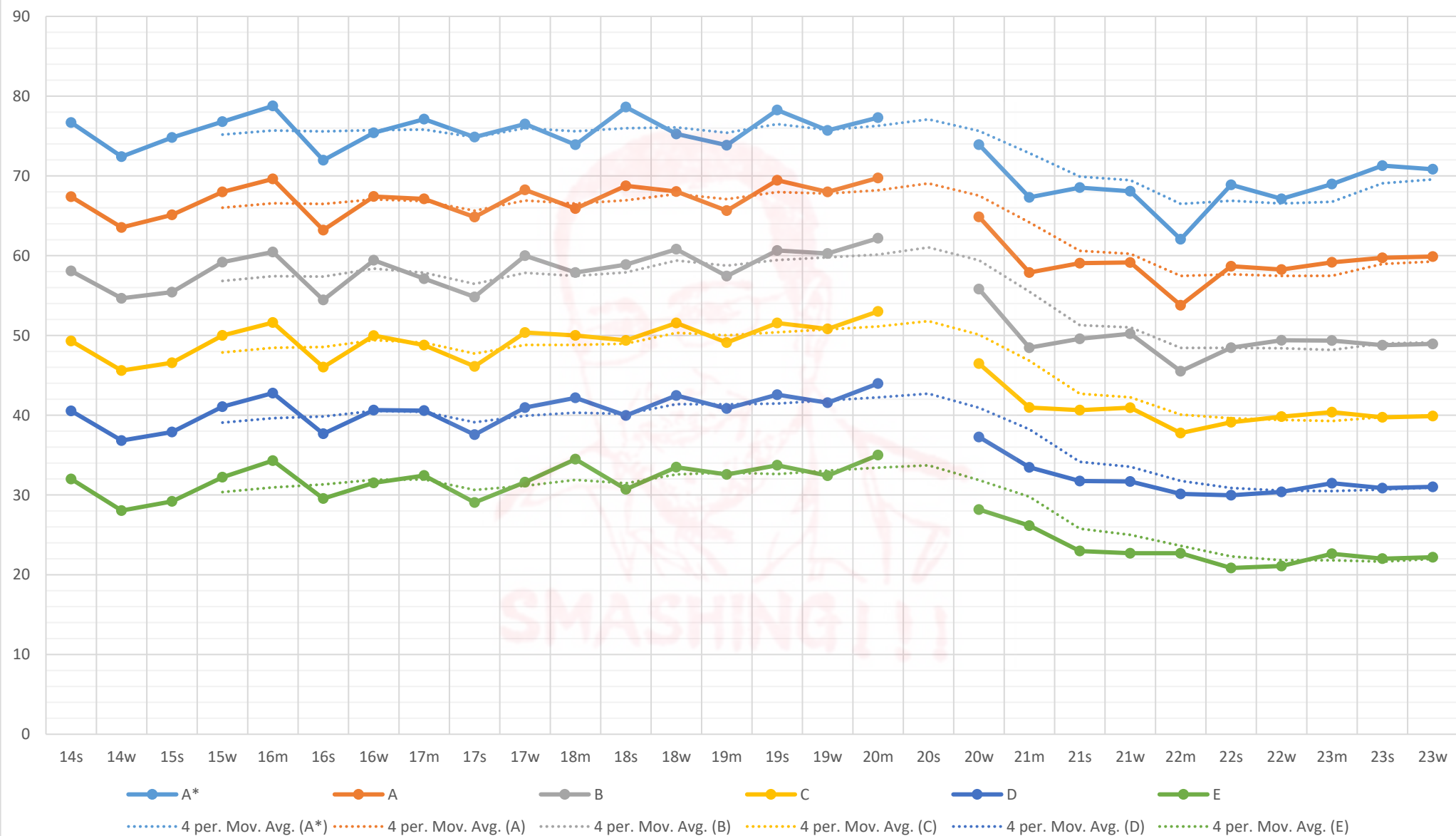


²⁹ <https://www.cao.cam.ac.uk/ums-performance-and-eventual-he-destination-cambridge-applicants>

UMS Score of Successful vs Unsuccessful Cambridge Applicants by (Tripos) Subject



CIE AS Chemistry 9701 Grade boundaries from 2014s to 2023w average % of all variants of component combinations awarding the A Level



How does Cambridge process grades and UMS scores?³⁰

This table was created from a Freedom of Information (FOI) request. Cambridge is unusual in that they always ask for UMS scores for all applicants. But it also seems that exceptional AS results are stored in a different way to all other results (results in green, 781 total results for 317 total unique ApplyID candidates almost all not shown here).

A total of 1054 candidates had A Level results in this data set. It is not explained why there is such a mismatch between the number of AS results held and the A Level results. The random anonymising ApplyID for the two tables from the original pdf do not seem to match. A total of 84 unique ApplyID numbers were made offers from this AS results cohort, against a total of 271 of students with A Level Results who were made offers from the same Apply Year with the same FOI document. Most offers were made then to students who did not have AS results.

At least 2 students who had flawless UMS scores (shown in yellow below) in at least some of the AS levels were not offered a place.

The CAIE international exam board is contained within the Title of the subject, as shown at 300007 (highlighted blue), indicating that some differentiation is made with regards to the same subject from different exam boards. In this case, and everywhere else, just because information has been stored does not mean it was all reported here, and just because it was does not mean it was used, or even that those making decisions had access to it.

Course	Apply Year	ApplyID	Offer Holder	Qualification	Title	Result	Additional Info
Natural Sciences (Physical)	2020	300172	Yes	GCE Advanced Subsidiary	Chemistry	a 92	92
Natural Sciences (Physical)	2020	300172	Yes	GCE Advanced Subsidiary	Physics	a 95	95
Natural Sciences (Physical)	2020	300082	Yes	GCE Advanced Subsidiary	Chemistry	A- 200/200	200/200
Natural Sciences (Physical)	2020	300082	Yes	GCE Advanced Subsidiary	Physics	A- 200/200	200/200
Natural Sciences (Physical)	2020	300082	Yes	GCE Advanced Subsidiary	Mathematics	A- 240/240	240/240
Natural Sciences (Physical)	2020	300083		GCE Advanced Subsidiary	Physics	A (111/160)	(111/160)
Natural Sciences (Physical)	2020	300083		GCE Advanced Subsidiary	Chemistry	A (127/160)	(127/160)
Natural Sciences (Physical)	2020	300083		GCE Advanced Subsidiary	Further Mathematics	A (130/160)	(130/160)
Natural Sciences (Physical)	2020	300083		GCE Advanced Subsidiary	Mathematics	A (153/160)	(153/160)
Natural Sciences (Physical)	2020	300233		GCE Advanced Subsidiary	Physics	A- 196/200	196/200
Natural Sciences (Physical)	2020	300233		GCE Advanced Subsidiary	Chemistry	A- 200/200	200/200
Natural Sciences (Physical)	2020	300233		GCE Advanced Subsidiary	Mathematics	A- 239/240	239/240
Natural Sciences (Physical)	2020	300212		GCE Advanced Subsidiary	Chemistry	A-200/200	200/200
Natural Sciences (Physical)	2020	300212		GCE Advanced Subsidiary	Physics	A-200/200	200/200
Natural Sciences (Physical)	2020	300212		GCE Advanced Subsidiary	Mathematics A	A-240/240	240/240
Natural Sciences (Physical)	2020	300006	Yes	GCE Advanced Subsidiary	Chemistry	A	
Natural Sciences (Physical)	2020	300006	Yes	GCE Advanced Subsidiary	Physics	A	
Natural Sciences (Physical)	2020	300007		GCE Advanced Subsidiary	Biology 9700	A	
Natural Sciences (Physical)	2020	300007		GCE Advanced Subsidiary	Mathematics 9709	A	
Natural Sciences (Physical)	2020	300007		GCE Advanced Subsidiary	Physics 9702	A	
Natural Sciences (Physical)	2020	300007		GCE Advanced Subsidiary	Chemistry 9701	B	
Natural Sciences (Physical)	2020	300008		GCE Advanced Subsidiary	Chemistry	A	
Natural Sciences (Physical)	2020	300008		GCE Advanced Subsidiary	Mathematics	A	
Natural Sciences (Physical)	2020	300008		GCE Advanced Subsidiary	Physics	A	
Natural Sciences (Physical)	2020	300009		GCE Advanced Subsidiary	Chemistry	A	
Natural Sciences (Physical)	2020	300009		GCE Advanced Subsidiary	Mathematics	A	
Natural Sciences (Physical)	2020	300009		GCE Advanced Subsidiary	Physics	A	

In the same document³¹ we can see here some of the overall A Level results after 2 years of study 1054 unique ApplyIDs in total, most of this data is not shown here.

Course	Apply Year	A Level App	ApplyID	Offer Holder	A Level Results
Natural Sciences (Physical)	2020	Yes	401013		Mathematics: A, Further Mathematics: B, Physics: B
Natural Sciences (Physical)	2020	Yes	401014	Yes	Mathematics: A, Further Mathematics: C, Physics B (Advancing Physics): D
Natural Sciences (Physical)	2020	Yes	401015		Mathematics: A, Music: A, Physics (Astrophysics): A
Natural Sciences (Physical)	2020	Yes	400036		Biology: A*, Chemistry B (Salters): A*, Further Mathematics A: A*, Mathematics A: A*, Physics (Turning Points): A*

They evidently have and store all A Level results of all applicants, including students who are not made an offer, which might help them measure a school's effectiveness at making reliable predictions at A2 level.

³⁰ <https://www.whatdotheyknow.com/request/statistics-for-applicants-for-ph>

³¹ <https://www.whatdotheyknow.com/request/statistics-for-applicants-for-ph>



Top 15 performing UCAS Apply Centres in 2022 for Cambridge³²

#	UCAS Apply Centre	School Name	School Sector	Apps	Offers	Accept.	Offer rate %	2 Years?	Notes	Reference
1	15326	Brampton Manor Academy	Maintained	205	65	72	32	?	No info on syllabus on website or prospectus	https://www.bramptonmanor.org/Information/Prospectus/
2	48056	Raffles Junior College, Singapore	Other and Overseas	129	49	39	38	?	Uses a H1, H2 and H3 SEAB Singapore Examinations Board	https://www.ri.edu.sg/
3	12060	Westminster School	Independent	86	35	34	41	2 Years	Now study CAIE A Level Chemistry; might do combined instead of individual exams, in 2023 study PreU Chemistry	https://www.westminster.org.uk/academic-life/exam-results-he/
4	45199	Hwa Chong Institution, Singapore	Other and Overseas	92	34	27	37	?	Doesn't study A level. "The Hwa Chong Integrated Programme (IP) is designed by our own teachers who have years of experience teaching high ability students"	https://www.hci.edu.sg/high-school/academic-prog/
5	13040	Brighton Hove and Sussex Sixth Form College	Maintained	133	31	20	23	2 Years	"all culminate in final exams at the end of two years."	https://www.bhasvic.ac.uk/courses/sixth-form-study
6	11078	Queen Elizabeth's School, Barnet	Maintained	69	29	28	42	?	AQA AS and A Level syllabi followed, but not easy to see if all exams are at the end of A2 year.	https://www.qebarnet.co.uk/academic-programme/our-curriculum/
7	10172	Hills Road Sixth Form College	Maintained	101	27	26	27	?	OCR Chemistry; cannot see if it has AS exams, or all at the end	https://www.hillsroad.ac.uk/study-with-us/a-level-subjects/chemistry
8	10642	King Edward VI Grammar School, Chelmsford	Maintained	58	24	22	41	2 Years	OCR Chemistry. "Total of 6 hours of exams (2 x 2 hours 15 minutes and 1 x 1 hour 30 minutes) taken at the end of the course."	https://www.kegs.org.uk/filedownload/5795FCB9-CFF7-2D4D-2F9C8875F60539AF.pdf/kegs-sixth-form-options-booklet-for-september-2024.pdf
9	11055	Peter Symonds College	Maintained	82	23	20	28	2 Years	"Methods & Patterns of Assessment. A Level: End of Year 2. Three exams of approx. 2 hours each."	https://psc.ac.uk/study/course/chemistry
10	45346	Shenzhen College of International Education	Other and Overseas	92	23	18	25	?	CAIE A Levels, but cannot see from website if they have all exams at the end, but likely have AS exams.	https://www.scie.com.cn/subject-chemistry/
11	11815	St Paul's School, London	Independent	69	22	21	32	?	"Nearly half the year group studies chemistry at A Level, following the OCR A syllabus."	https://www.stpaulsschool.org.uk/academic/academic-13-16/subjects/chemistry/
12	12092	King's College School	Independent	65	21	20	32	?	Cannot see curriculum details	https://www.kcs.org.uk/senior-school
13	12528	Magdalen College School, Oxford	Independent	72	21	20	29	2 Years	"Assessed through public exams in the summer of the Upper Sixth [A2]"	https://www.mcsoxford.org/senior-school/academic/subjects/chemistry/
14	11947	Henrietta Barnett School	Maintained	45	21	20	47	2 Years	"There are no External exams in Year 12"	https://www.hbschool.org.uk/academic-programme/departments/sciences/
15	12041	Wilson's School	Maintained	55	21	22	38	1 Year	Year 12 students currently sit the AS examination at the end of Year 12.	https://www.wilsons.school/curriculum/dept/chemistry/

³² <https://www.undergraduate.study.cam.ac.uk/sites/www.undergraduate.study.cam.ac.uk/files/publications/undergraduate-admissions-by-apply-centre-2022-cycle.pdf>
www.SmashingScience.org



Key takeaways:

Only one school of the top 15 obviously takes the AS exams at the end of the first (AS) 6th form year. Of the schools that do provide information about the structure of their exams at A levels on their websites, 6 schools have used a 2 year program with all exams at the end. One explanation for why so few AS results were in the FOI dataset used previously³³ is because most students applying to Cambridge do not take the AS exams.

Schools that have a stronger reputation with Cambridge, for instance because their A level predictions are more reliable (or other reasons), might opt for the 2-year approach which might have advantages with a variety of university applications. For instance, it avoids the substantial levels of difficulties in gaining 95% UMS in the AS year Cambridge have reported on. Students from newer schools, and others, which have a less well-established reputation might benefit instead from the AS UMS exam scores.



³³ https://www.whatdotheyknow.com/request/statistics_for_applicants_for_ph
www.SmashingScience.org

A Level grade profiles for 2022

Table 4.1 Home applications, offers and acceptances to Cambridge by A Level profile and gender 2022³⁴

A Level Grades	Applications						Offers						Acceptances					
	Male	%	Female	%	Total	%	Male	%	Female	%	Total	%	Male	%	Female	%	Total	%
Arts, Humanities and Social Sciences																		
A*A*A*	826	12.9	1,043	16.0	1,869	14.5	279	19.7	435	28.2	714	24.1	281	23.1	441	32.5	722	28.1
A*A*A	485	7.6	831	12.7	1,316	10.2	104	7.3	253	16.4	357	12.1	109	9.0	260	19.2	369	14.3
A*A*B	52	0.8	80	1.2	132	1.0	14	1.0	16	1.0	30	1.0	9	0.7	15	1.1	24	0.9
A*A*C	3	0.0	8	0.1	11	0.1	0	0.0	1	0.1	1	0.0	0	0.0	0	0.0	0	0.0
A*AA	357	5.6	573	8.8	930	7.2	74	5.2	126	8.2	200	6.8	66	5.4	124	9.1	190	7.4
A*AB	127	2.0	245	3.8	372	2.9	19	1.3	37	2.4	56	1.9	8	0.7	17	1.3	25	1.0
AAA	126	2.0	231	3.5	357	2.8	14	1.0	25	1.6	39	1.3	7	0.6	11	0.8	18	0.7
<AAA	382	6.0	799	12.2	1,181	9.1	33	2.3	63	4.1	96	3.2	2	0.2	2	0.1	4	0.2
Subtotals	2,358	36.8	3,810	58.3	6,168	47.7	537	38.0	956	61.9	1,493	50.5	482	39.7	870	64.1	1,352	52.6
Sciences																		
A*A*A*	2,066	32.3	1,106	16.9	3,172	24.5	739	52.2	469	30.4	1,208	40.8	659	54.2	423	31.2	1,082	42.1
% of science cohort		30.5		16.4		46.9		50.4		32.0		82.4		54.0		34.7		88.7
A*A*A	663	10.4	417	6.4	1,080	8.4	90	6.4	59	3.8	149	5.0	64	5.3	45	3.3	109	4.2
A*A*B	22	0.3	27	0.4	49	0.4	3	0.2	4	0.3	7	0.2	0	0.0	1	0.1	1	0.0
A*A*C	0	0.0	1	0.0	1	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
A*AA	511	8.0	381	5.8	892	6.9	31	2.2	31	2.0	62	2.1	10	0.8	12	0.9	22	0.9
A*AB	149	2.3	103	1.6	252	1.9	3	0.2	6	0.4	9	0.3	0	0.0	0	0.0	0	0.0
AAA	198	3.1	176	2.7	374	2.9	4	0.3	10	0.6	14	0.5	0	0.0	5	0.4	5	0.2
<AAA	432	6.8	512	7.8	944	7.3	8	0.6	9	0.6	17	0.6	0	0.0	1	0.1	1	0.0
Subtotals	4,041	63.2	2,723	41.7	6,764	52.3	878	62.0	588	38.1	1,466	49.5	733	60.3	487	35.9	1,220	47.4
Totals	6,399	100.0	6,533	100.0	12,932	100.0	1,415	100.0	1,544	100.0	2,959	100.0	1,215	100.0	1,357	100.0	2,572	100.0

Key takeaways:

- Science students academically perform better than other students; almost all of them have 3 A*. Almost no students are admitted to science with less than A*A*A.
- There is a strong gender split in the number of applications, but this is closed slightly at the “Offers” and “Acceptances” stages.
- It may be possible to infer a possible ranking order for non A*A*A* profiles, e.g. A*A*C could be higher than A*AA; A*AB could be higher than AAA.

³⁴ https://www.undergraduate.study.cam.ac.uk/sites/www.undergraduate.study.cam.ac.uk/files/publications/undergraduate-admissions_by_apply_centre_2022_cycle.pdf
www.SmashingScience.org



Looking at the entrance exam and the interview score together

The NSAA is just one part of the process, but looking at averages for it and accepted students, doing better in it will likely ensure you get an interview (no students with an unusually high score in it were denied an interview, but students with lower scores get accepted, and higher scores get rejected).

St John's College has published analysis for 2020 application year (these students would have sat the entrance exam in 2019, which involved the older Section 2 paper that had short answer questions, not MCQ).³⁵:

		Min	Min %	Mean	Mean %	Max	Max %
Made offers	Section 1	9	25.0(a)	18.05	50.1(b)	27	75.0(c)
Winter Pool	Section 1	6.8	18.9	14.86	41.3(d)	25.6	71.1
Invited for interview (e)	Section 1	6.8	18.9	17.02	47.3	27	75.0
Rejected	Section 1	3.1	8.6	11.51	32.0(f)	25.8	71.7
Not invited for interview	Section 1	3.1	8.6	11.95	33.2	22.3	61.9(g)

Made offers	Section 2	11	27.5	28.27	70.7	40	100.0
Winter Pool	Section 2	6	15.0	22.91	57.3	38	95.0
Invited for interview	Section 2	6	15.0	26.32	65.8	40	100.0
Rejected	Section 2	3	7.5	19.79	49.5	36.5	91.3
Not invited for interview	Section 2	3	7.5	20.49	51.2	37	92.5(h)

Interview score	Accepted	7	70(i)	7.89	78.9	9.3	93
Interview score	Rejected	4.3	43	6.43	64.3	8.5	85

Logically relevant statements possible with this data working left to right, top to down):

- Some students who are made offers perform really poorly in the entrance exam.
- About half of students who were made an offer scored 50% or less on the MCQ part of the exam.
- All students missed at least 1 in 4 marks, including the best accepted students.
- Students who were placed in winter pool, so considered really good applicants by Cambridge standards, but whose applications were for an unusually (for Cambridge) competitive group, were on average lower performing than their average applicant that went for interview. This could indicate that St John's college is unusually competitive in larger proportion of places than the average college. AND/OR winter pool represents students who did unusually well in an interview. Which could be an indication that good interviews have a stronger impact.
- More than half, perhaps as many as 80% of applicants are invited for interview, so only a small amount of selection has happened to get to this point, but likely the poorest performing quintile are likely removed by that process.
- Students rejected do substantially less well than those who were made offers showing a clear correlation: doing better on the NSAA is linked in some way to a higher rate of acceptance.
- Students who were not invited to interview included some who scored higher than about half of those accepted, indicating that success in the NSAA does not overcome whatever other challenges those students had that caused them to be rejected. Possibly these students had lower AS UMS/PUM scores, for instance.
- One student got nearly a perfect score (37) for section 2 but was not invited to interview, they could have had a problem with their GCSE or AS grades, or also possible, a problem with their personal statement (e.g. plagiarised) or their reference
- All students who were made offers received a good interview score. It is not easy to know what information the interviewer has about the applicant before the interview. The social sciences might have made some inroads on delivering effective, reproducible interview style inquiries, but it is unclear what protocols are followed or why for the Cambridge (or Oxford) interview process.

Key take away:

Higher test scores do track with acceptance, but they are obviously not the only or most important part to the selection process. Interestingly, there is a scoring process for the interview.

To find out about Winter Pool go here:

https://www.undergraduate.study.cam.ac.uk/sites/www.undergraduate.study.cam.ac.uk/files/publications/guide_to_the_winter_pool_0.pdf

³⁵ https://www.whatdotheyknow.com/request/natural_sciences_applications_20_21
www.SmashingScience.org



Impact of GCSEs on acceptance rate

From Natural Sciences A level admissions data for 2020 (excludes IB and other qualifications)³⁶

Percentile	Total A* Acpt.	A* Rej.	Not A* Acpt.	Not A* Rej.	Total GCSE Acpt.	Total GCSE Rej.	% A* to all Acpt.	% A* to all Rej.	% (A*+A) to all Acpt.	% (A*+A) to all Rej.
0.01 LEAST	3	0	0	0	4	1	38	0	60	33
0.05	4	2	0	0	6	4	50	20	71	50
0.10	5	3	0	0	7	5	60	36	80	64
0.20	7	5	0	1	9	7	73	50	90	76
0.40	9	6	1	2	10	9	86	64	100	90
0.50	9	7	1	3	10	9	90	73	100	91
0.60	10	8	1	3	10	10	91	80	100	100
0.80	10	9	3	5	11	10	100	90	100	100
0.90	11	10	4	6	11	11	100	100	100	100
0.95	11	11	5	7	12	12	100	100	100	100
1.00 MOST	13	13	8	11	14	13	100	100	100	100

	GCSE A* Count	GCSE A Count	GCSE Other Count	Total	Non A* Total	% A* to all	% (A*+A) to all
Average Accepted	8.6	1.0	0.5	10.1	1.5	85.2	95.0
Averages Rejected	6.9	1.8	1.2	9.9	3.0	68.7	86.8

	A Level Applicants	Offer Holder	No offer
Totals	983	251	732

Key takeaway:

Most students who get offers have about 9A*, and almost all of them, about 80% have 7. A large number of student with a majority of A* get rejected. Almost half of all rejected students (and therefore a larger number of students than the number made offers) only have A* and A GCSEs.

Most students made offers have only A* or A grades, but students with one, and sometimes two B grades or lower are also accepted, but only about 1%, or 10 students a year, are admitted with a substantial proportion of grades lower than A.

The number of A* is less important than the ratio of A* to non A* (which is also stated on their website).

³⁶ https://www.whatdotheyknow.com/request/statistics_for_applicants_for_ph
www.SmashingScience.org



	Totals	Maths	Physics	Biology	Chemistry	Advanced Maths	Section 2 B1	Section 2 B2	Section 2 C1	Section 2 C2	Section 2 P1	Section 2 P2
Offer Made NSAA Averages %		75.8	66.0	66.3	61.8	55.2	N/A	65.0	69.2	69.0	64.4	55.3
Rejected NSAA Averages %		57.5	43.5	43.8	42.6	30.7	33.7	53.1	47.4	50.7	42.6	40.1
Offer made total candidates	270	269	256	43	154	84	0	3	137	131	104	165
Rejected total candidates	775	775	714	79	447	292	17	26	368	303	364	470
Total applicants attempting NSAA part	1045	1044	970	122	601	376	17	29	505	434	468	635
Success rate %	26	26	26	35	26	22	0	10	27	30	22	26

NSAA Section 1 Results by percentile group from 2020 entry year³⁸

Larger percentile represents a thresholds above which increasingly smaller numbers of more highly performing students were placed. Where higher scores are found at lower percentiles it indicates that higher scores were more common out of all exams taken.

Percentile	Maths S1 Accepted	Maths S1 Rejected	Physics S1 Accepted	Physics S1 Rejected	Biology S1 Accepted	Biology S1 Rejected	Chemistry S1 Accepted	Chemistry S1 Rejected	Advanced Maths Accepted	Advanced Maths Rejected
Average%	75.8	57.5	66.0	43.5	66.3	43.8	61.8	42.6	55.2	30.7
0.01	39	17	20	6	11	10	28	6	5	0
0.05	50	28	33	17	24	17	37	17	28	6
0.10	56	33	39	22	46	21	44	22	33	11
0.20	61	44	50	28	50	33	50	28	39	17
0.40	72	56	61	39	67	39	61	39	44	28
0.50	78	56	67	39	72	44	61	44	56	28
0.60	83	61	72	44	73	50	67	44	61	33
0.80	89	72	83	61	81	58	74	56	74	44
0.90	94	83	89	67	83	61	78	61	83	50
0.95	100	89	94	78	88	67	83	67	94	61
1.00	100	100	100	100	89	83	94	94	100	89

Even at the highest level, for most sciences students who were rejected had lower scores than around 30-40% of those candidates accepted. The mean average tends to be around 40-50% better for all subjects for those made an offer compared to those who completed the same part but were rejected.

The students who were in the highest decile (0.90 to 1.00) tended to get scores that were at often as good as more than half of the students who were accepted. And the highest scores of the best of those rejected often were as good as those who were accepted. So exceptionally achieving students were sometimes rejected. Possibly as a result of their score in other parts of the exam, which was not considered here.

But the lowest scores of students accepted in the lowest decile (0.01 to 0.10) tend to be roughly in line with the mean of those rejected, implying about half the rejected cohort got a score as good or better. So a lower score can still result in an offer.

Biology in section 1 was the lowest scoring at the highest levels of those accepted, which was reflected in having the highest success rate for those who attempted it (35% success for biology against an overall average success rate of 26%)

³⁷ https://www.whatdotheyknow.com/request/statistics_for_applicants_for_ph

³⁸ https://www.whatdotheyknow.com/request/statistics_for_applicants_for_ph
www.SmashingScience.org

NSAA and Veterinary Medicine³⁹

It is not clear if these average scores are of those made offers, accepted or successful, or just the overall average of all applicants.

Also, the score may be out of 18 (raw total) or 10, which would be calculated, like the UMS/PUM from the raw score. It seems likely that this Section 1 scores are out of 9 (like for GCSEs), which would put them roughly in line with the averages seen from more clearly explained data⁴⁰.

More information about averages (this time for the Veterinary Science course) can be found here:

Course	Accepted	Apply Year	NSAA Section	Section	Average score	Average %
Veterinary Medicine (D100)	NSAA	2018	Advanced Maths	1	5.4	
Veterinary Medicine (D100)	NSAA	2018	Biology	1	4.3	
Veterinary Medicine (D100)	NSAA	2019	Biology	1	4.6	
Veterinary Medicine (D100)	NSAA	2020	Biology	1	4.4	
Veterinary Medicine (D100)	NSAA	2021	Biology	1	5.0	
Veterinary Medicine (D100)	NSAA	2018	Chemistry	1	4.1	
Veterinary Medicine (D100)	NSAA	2019	Chemistry	1	4.6	
Veterinary Medicine (D100)	NSAA	2020	Chemistry	1	4.8	
Veterinary Medicine (D100)	NSAA	2021	Chemistry	1	2.6	
Veterinary Medicine (D100)	NSAA	2018	Maths	1	3.7	
Veterinary Medicine (D100)	NSAA	2019	Maths	1	3.5	
Veterinary Medicine (D100)	NSAA	2020	Maths	1	3.4	
Veterinary Medicine (D100)	NSAA	2021	Maths	1	3.7	
Veterinary Medicine (D100)	NSAA	2018	Physics	1	3.8	
Veterinary Medicine (D100)	NSAA	2019	Physics	1	3.3	
Veterinary Medicine (D100)	NSAA	2020	Physics	1	5.0	
Veterinary Medicine (D100)	NSAA	2021	S2 Biology	2	4.4	
Veterinary Medicine (D100)	NSAA	2021	S2 Chemistry	2	3.6	
Veterinary Medicine (D100)	NSAA	2018	Section 2 B1	2	11.8	59
Veterinary Medicine (D100)	NSAA	2019	Section 2 B1	2	11.4	57
Veterinary Medicine (D100)	NSAA	2020	Section 2 B1	2	8.3	42
Veterinary Medicine (D100)	NSAA	2018	Section 2 B2	2	12.2	61
Veterinary Medicine (D100)	NSAA	2019	Section 2 B2	2	12.4	62
Veterinary Medicine (D100)	NSAA	2020	Section 2 B2	2	11.6	58
Veterinary Medicine (D100)	NSAA	2018	Section 2 C1	2	12.7	64
Veterinary Medicine (D100)	NSAA	2019	Section 2 C1	2	15.2	76
Veterinary Medicine (D100)	NSAA	2020	Section 2 C1	2	10.7	54
Veterinary Medicine (D100)	NSAA	2018	Section 2 C2	2	14.7	74
Veterinary Medicine (D100)	NSAA	2019	Section 2 C2	2	11.4	57
Veterinary Medicine (D100)	NSAA	2020	Section 2 C2	2	11.2	56
Veterinary Medicine (D100)	NSAA	2018	Section 2 P1	2	7.5	38
Veterinary Medicine (D100)	NSAA	2018	Section 2 P2	2	9.0	45

A good explanation for this wide variability in scores is the emphasis this course places on other things, most likely a strong personal statement and portfolio of experiences related to the subject.

³⁹ https://www.whatdotheyknow.com/request/admission_statistics_for_undergr_23#incoming-1995334

⁴⁰ https://www.whatdotheyknow.com/request/statistics_for_applicants_for_ph
www.SmashingScience.org



Analysis of MCQ answer frequencies

Averages																				
All subjects	s1 & s2%	s1	s2	2020+ %	s1 2016SP %	s1 2016 %	s1 2017 %	s1 2018 %	s1 2019 %	s1 2020sp %	s1 2020 %	s1 2021 %	s1 2022 %	s1 2023 %	ESAT %	s2 2020sp %	s2 2020 %	s2 2021 %	s2 2022sp %	s2 2022 %
A	12.9	12.9	13	12.8	14 16	10 11	11 12	14 16	8 9	12 15	10 13	11 14	9 11	10 13	6 21	6 20	5 8	4 7	6 20	6 10
B	14.2	14.3	14	13.8	14 16	11 12	16 18	11 12	12 13	14 18	9 11	12 15	11 14	14 18	2 7	3 10	10 17	8 13	5 17	8 13
C	17.2	17.9	16	15.5	18 20	20 22	16 18	20 22	17 19	13 16	12 15	11 14	12 15	10 13	7 24	5 17	10 17	11 18	5 17	7 12
D	16.5	18.2	13	14.4	22 24	16 18	17 19	9 10	17 19	20 25	12 15	12 15	15 19	12 15	6 21	1 3	14 23	11 18	1 3	11 18
E	17.9	16.2	21	19.1	13 14	12 13	14 16	20 22	16 18	12 15	10 13	14 18	14 18	19 24	6 21	9 30	8 13	10 17	8 27	11 18
F	9.8	10.2	9	11.1	6 7	9 10	8 9	8 9	9 10	3 4	17 21	11 14	7 9	8 10	2 7	1 3	6 10	7 12	2 7	8 13
G	7.2	6.3	9	9.0	1 1	7 8	4 4	4 4	5 6	4 5	7 9	5 6	11 14	4 5	0 0	2 7	5 8	6 10	2 7	7 12
H	4.3	4.0	5	4.4	2 2	5 6	4 4	4 4	6 7	2 3	3 4	4 5	1 1	3 4	0 0	3 10	2 3	3 5	1 3	2 3
Totals	1119	100.0		100.0	90	90	90	90	90	80	80	80	80	80	29	30	60	60	30	60
Chemistry	s1 & s2%	s1	s2	2020+ %	s1 2016SP %	s1 2016 %	s1 2017 %	s1 2018 %	s1 2019 %	s1 2020sp %	s1 2020 %	s1 2021 %	s1 2022 %	s1 2023 %	ESAT %	s2 2020sp %	s2 2020 %	s2 2021 %	s2 2022sp %	s2 2022 %
A	13.7	8.0	6.6	12.5	4 22	2 11	2 11	4 22	1 6	4 20	1 5	3 15	3 15	2 10	5 19	2 20	1 5	1 5	2 20	3 15
B	13.2	6.1	9.4	15.6	1 6	0 0	2 11	3 17	3 17	2 10	2 10	3 15	2 10	2 10	2 7	1 10	5 25	3 15	2 20	4 20
C	17.5	11.0	9.1	15.0	4 22	7 39	2 11	5 28	1 6	4 20	2 10	4 20	3 15	4 20	7 26	2 20	4 20	4 20	1 10	1 5
D	18.7	12.2	7.6	15.0	3 17	5 28	7 39	2 11	4 22	5 25	4 20	2 10	3 15	3 15	6 22	1 10	3 15	4 20	1 10	4 20
E	20.7	11.7	11.7	21.3	6 33	1 6	3 17	3 17	4 22	5 25	4 20	5 25	4 20	6 30	5 19	3 30	3 15	3 15	3 30	3 15
F	9.2	5.6	3.1	11.3	0 0	3 17	1 6	1 6	2 11	0 0	5 25	3 15	2 10	1 5	2 7	0 0	1 5	3 15	0 0	4 20
G	4.7	1.2	4.6	7.5	0 0	0 0	0 0	0 0	1 6	0 0	2 10	0 0	2 10	1 5	0 0	1 10	2 10	1 5	1 10	1 5
H	2.3	1.2	1.3	1.9	0 0	0 0	1 6	0 0	2 11	0 0	0 0	0 0	1 5	1 5	0 0	0 0	1 5	1 5	0 0	0 0
Totals	297	100.0		100.0	18	18	18	18	18	20	20	20	20	20	27	10	20	20	10	20
Numbers of MCQs in Chemistry that have a certain number of answers:					s1 2016SP	s1 2016	s1 2017	s1 2018	s1 2019	s1 2020sp	s1 2020	s1 2021	s1 2022	s1 2023	ESAT	s2 2020sp	s2 2020	s2 2021	s2 2022sp	s2 2022
2020+ % s1 Only Possible answer # s1 & s2					%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
1 4 0					13 72	4 22	2 11	4 22	6 33	14 70	3 15	9 45	3 15	3 15	17 63	1 10	3 15	5 25	1 10	4 20
25 34 5 28					5 28	7 39	9 50	8 44	5 28	6 30	5 25	6 30	6 30	6 30	7 26	3 30	6 30	6 30	3 30	5 25
28 33 6 32					8 40	2 11	1 6	3 17	1 6	1 5	1 5	1 5	1 5	2 7	2 7	1 10	1 5	5 25	1 10	3 15
9 5 7 8					37 27 8 32	5 28	7 39	3 17	6 33	0	10 50	5 25	10 50	10 50	0	5 50	10 50	4 20	5 50	8 40
100 100 Totals					18 100	18 100	18 100	18 100	18 100	20 100	20 100	20 100	20 100	20 100	27 96	10	20	20	10	20
Biology	s1 & s2%	s1	s2	2020+ %	s1 2016SP %	s1 2016 %	s1 2017 %	s1 2018 %	s1 2019 %	s1 2020sp %	s1 2020 %	s1 2021 %	s1 2022 %	s1 2023 %		s2 2020sp %	s2 2020 %	s2 2021 %	s2 2022sp %	s2 2022 %
A	10.7	6.8	5.2	10.6	1 6	1 6	3 17	2 11	2 11	3 15	2 10	4 20	2 10	3 15		1 10	3 15	1 5	1 10	1 5
B	12.7	8.0	6.0	11.3	2 11	4 22	3 17	2 11	2 11	3 15	1 5	4 20	3 15	3 15		0 0	3 15	4 20	1 10	1 5
C	12.6	7.2	7.2	13.8	1 6	3 17	4 22	1 6	3 17	0 0	4 20	3 15	2 10	0 0		1 10	3 15	2 10	2 20	2 10
D	14.5	8.8	5.8	13.1	5 28	2 11	2 11	1 6	4 22	4 20	1 5	4 20	4 20	3 15		0 0	5 25	3 15	0 0	4 20
E	15.2	6.5	12.3	16.3	1 6	4 22	1 6	5 28	2 11	2 10	1 5	1 5	1 5	5 25		4 40	1 5	4 20	3 30	4 20
F	13.7	8.4	6.4	14.4	5 28	1 6	2 11	3 17	0 0	3 15	7 35	1 5	4 20	4 20		1 10	2 10	2 10	2 20	1 5
G	11.7	5.4	6.3	13.1	1 6	1 6	1 6	2 11	2 11	4 20	2 10	1 5	4 20	2 10		1 10	2 10	3 15	1 10	5 25
H	9.0	6.0	4.0	7.5	2 11	2 11	2 11	2 11	3 17	1 5	2 10	2 10	0 0	0 0		2 20	1 5	1 5	0 0	2 10
Totals	270	100.0		100.0	18	18	18	18	18	20	20	20	20	20		10	20	20	10	20
Mathematics	s1 & s2%	s1	s2	2020+ %	s1 2016SP %	s1 2016 %	s1 2017 %	s1 2018 %	s1 2019 %	s1 2020sp %	s1 2020 %	s1 2021 %	s1 2022 %	s1 2023 %						
A	12.2	7.4	####	15.0	4 22	2 11	0 0	2 11	1 6	4 20	4 20	3 15	1 5	2 10						
B	15.9	8.8	####	16.3	3 17	4 22	4 22	2 11	1 6	3 15	4 20	2 10	4 20	4 20						
C	19.6	11.2	####	15.0	5 28	4 22	3 17	5 28	4 22	5 25	2 10	1 5	4 20	4 20						
D	18.1	10.0	####	20.0	5 28	2 11	3 17	2 11	3 17	5 25	3 15	3 15	5 25	4 20						
E	16.5	9.2	####	16.3	1 6	3 17	3 17	4 22	4 22	2 10	3 15	4 20	4 20	4 20						
F	9.4	5.9	####	10.0	0 0	2 11	3 17	1 6	2 11	0 0	3 15	5 25	0 0	1 5						
G	5.9	3.1	####	5.0	0 0	1 6	2 11	1 6	2 11	0 0	1 5	1 5	2 10	0 0						
H	2.3	1.5	####	2.5	0 0	0 0	0 0	1 6	1 6	1 5	0 0	1 5	0 0	1 5						
Totals	190	100.0		100.0	18	18	18	18	18	20	20	20	20	20						

Major takeaways from this analysis

- The trends are stronger in chemistry than all (green indicates bias towards that letter answer), and weaker in biology (red indicates that that letter is less common).
- In chemistry ESAT 5 answers, A-E, is the most common question type. Previously 8 answers were more common.
- These trends exist across all papers from 2016sp to 2022, as well as for exam papers 2020sp and onwards.
- A correct answer could be any letter, but seems less likely if it is the first or the last option. So pure guesses at answer E would be optimal if these trends persist. If you had a fifty-fifty feeling for two answers, and one was at the end of the options, maybe go for the other answer.
- These trends are often found in other MCQ tests; it **WAS** in AS Chemistry offered by CAIE (**but that pattern was totally removed in 2023**).



Entrance statistics for selected non-UK applicants

Table 3.2 Applications, offers and acceptances to Cambridge by country 2022⁴¹

This table counts applications from outside the UK only.

Country of domicile	Applications		Offers		Acceptances and success rates		
	No.	%	No.	%	No.	%	Success rate (%)
China	2,169	28.7	294	29.5	224	30.4	10.3
Singapore	573	7.6	141	14.2	114	15.4	19.9
Hong Kong	572	7.6	91	9.1	73	9.9	12.8
United States of America	427	5.7	39	3.9	23	3.1	5.4
India	377	5.0	41	4.1	23	3.1	6.1
Malaysia	252	3.3	19	1.9	17	2.3	6.7
France	181	2.4	12	1.2	11	1.5	6.1
Canada	158	2.1	18	1.8	12	1.6	7.6
Ireland	156	2.1	17	1.7	13	1.8	8.3
Korea, Republic of	144	1.9	10	1.0	9	1.2	6.3
Spain	140	1.9	11	1.1	7	0.9	5.0
Germany	138	1.8	19	1.9	16	2.2	11.6
Pakistan	134	1.8	12	1.2	8	1.1	6.0
Australia	117	1.6	22	2.2	18	2.4	15.4
Poland	104	1.4	18	1.8	13	1.8	12.5
Italy	103	1.4	8	0.8	4	0.5	3.9
United Arab Emirates	92	1.2	11	1.1	7	0.9	7.6
Switzerland	91	1.2	14	1.4	13	1.8	14.3
Cyprus (European Union)	89	1.2	13	1.3	8	1.1	9.0
Thailand	79	1.0	9	0.9	8	1.1	10.1
Hungary	66	0.9	19	1.9	12	1.6	18.2
New Zealand	61	0.8	7	0.7	5	0.7	8.2
Romania	59	0.8	12	1.2	4	0.5	6.8
Belgium	51	0.7	6	0.6	5	0.7	9.8
Russian Federation	50	0.7	4	0.4	3	0.4	6.0
Other EU	387	5.1	52	5.2	37	5.0	9.6
Other International	775	10.3	77	7.7	51	6.9	6.6
Totals	7,545	100.0	996	100.0	738	100.0	9.8

⁴¹ <https://www.undergraduate.study.cam.ac.uk/apply/statistics>
www.SmashingScience.org



International, China, HK/TW/MAC and Singapore for 2019 to 2022 years of entry⁴²

Notable is Singapore's success rate, which has grown in 2022 to around twice that of the international average.

Entry Year	College	International (non-UK)				China				Hong Kong/Macao/Taiwan				Singapore			
		Apps.	Offer	Accept.	Offer rate %	Apps.	Offer	Accept.	Offer rate %	Apps.	Offer	Accept.	Offer rate %	Apps.	Offer	Accept.	Offer rate %
2019	Totals	6843	1127	852	18	1156	207	142	17	561	91	53	17	467	99	65	23
2020	Totals	6973	1110	827	17	1328	266	188	21	591	101	75	19	462	105	55	22
2021	Totals	7962	1088	800	15	1999	284	217	17	686	100	72	17	533	129	84	23
2022	Totals	7679	1042	771	15	2181	294	225	19	617	90	56	16	615	145	103	30

The numbers here for this table come from a Freedom of Information (FOI) request from the University, but they don't exactly line up with the universities published statistics in the previous table (Table 3.2), which will be produced to include more information, so ought to be considered more accurate to the message the University of Cambridge intends to deliver.

Proportion of total, %	China			Hong Kong/Macao/Taiwan			Singapore		
	Apps %	Offer %	Accept %	Apps %	Offer %	Accept %	Apps %	Offer %	Accept %
2019	16.9	18.4	16.7	8.2	8.1	6.2	6.8	8.8	7.6
2020	19.0	24.0	22.7	8.5	9.1	9.1	6.6	9.5	6.7
2021	25.1	26.1	27.1	8.6	9.2	9.0	6.7	11.9	10.5
2022	28.4	28.2	29.2	8.0	8.6	7.3	8.0	13.9	13.4

For more details about applications and colleges see at the back of this book: "Appendix - Admissions statistics for China, Hong Kong, Singapore and all International Students for 20109 to 2022 entry".

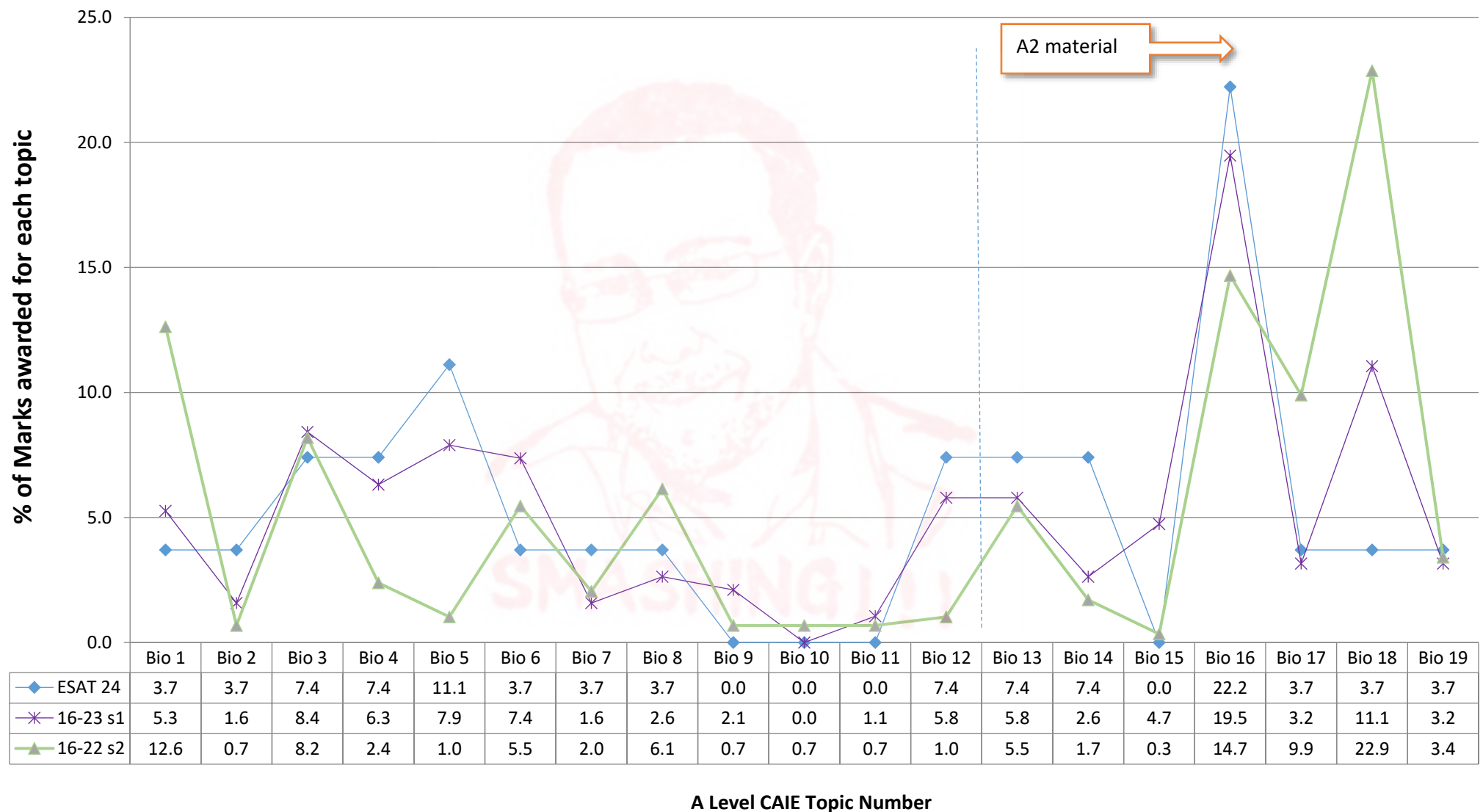
⁴² https://www.whatdotheyknow.com/request/undergraduate_admission_statisti_90
www.SmashingScience.org



Comparing marks allocated to each topic

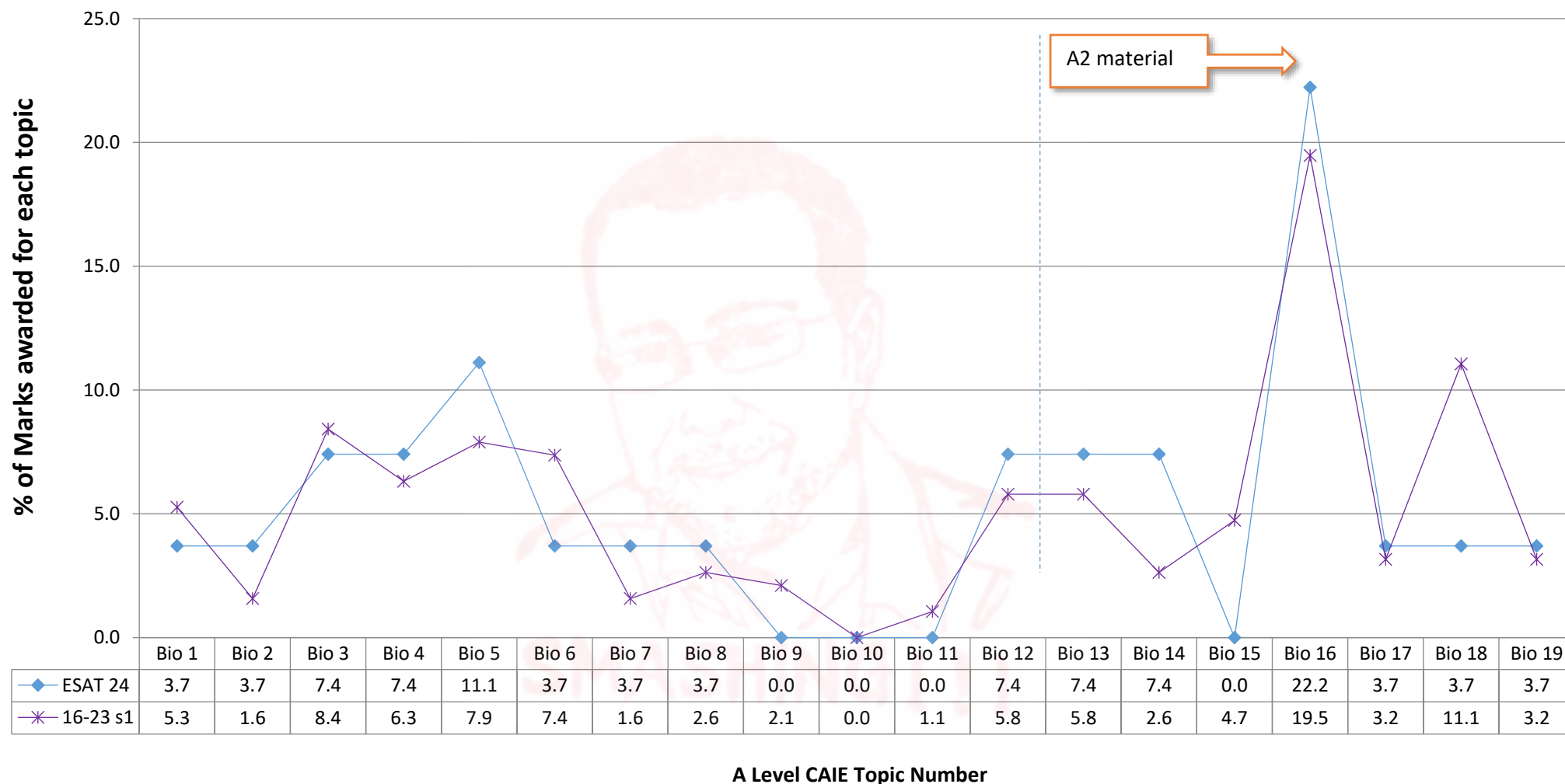
BIOLOGY Cambridge Entrance Exam **NSAA Section 1** and **ESAT**

Percentage of all marks awarded for each topic of the **NSAA Section 1** mapped to A Level from 2016 to 2023, **blue diamonds**, compared with **ESAT 2024 sample paper**, **purple crosses**, and **NSAA Section 2**, **green**



BIOLOGY Cambridge Entrance Exam **NSAA Section 1** and **ESAT**

Percentage of all marks awarded for each topic of the **NSAA Section 1** mapped to A Level from 2016 to 2023, **blue diamonds**, compared with **ESAT 2024 sample paper**, **purple crosses**



Comments on the distribution of marks

As the comparison with the most recent versus all of the exams, the general trends seem to be stable in which topics are examined more often. This was also true for Chemistry.

These topics are ordered by mark frequency for the most recent exams, which all use the 2023 new exam format. These map well with all of the exams, with the exception of topic 18 (Classification, biodiversity and conservation) which is substantially less in more recent exams, and topic 18 (HL acids and bases) which was less frequent, and is now even rarer.



ESAT mapped to A Level Biology Topics table

RANK	Ordered by topic frequency		ESAT 2024	NSAA 2016-23 Section 1	NSAA 2016-22 Section 2
8	AS	1 Cell structure	3.7	5.3	12.6
9	AS	2 Biological molecules	3.7	1.6	0.7
3	AS	3 Enzymes	7.4	8.4	8.2
4	AS	4 Cell membranes and transport	7.4	6.3	2.4
2	AS	5 The mitotic cell cycle	11.1	7.9	1.0
10	AS	6 Nucleic acids and protein synthesis	3.7	7.4	5.5
11	AS	7 Transport in plants	3.7	1.6	2.0
12	AS	8 Transport in mammals	3.7	2.6	6.1
17	AS	9 Gas exchange	0.0	2.1	0.7
19	AS	10 Infectious diseases	0.0	0.0	0.7
18	AS	11 Immunity	0.0	1.1	0.7
5	A2	12 Energy and respiration	7.4	5.8	1.0
6	A2	13 Photosynthesis	7.4	5.8	5.5
7	A2	14 Homeostasis	7.4	2.6	1.7
16	A2	15 Control and coordination	0.0	4.7	0.3
1	A2	16 Inheritance	22.2	19.5	14.7
13	A2	17 Selection and evolution	3.7	3.2	9.9
14	A2	18 Classification, biodiversity and conservation	3.7	11.1	22.9
15	A2	19 Genetic technology	3.7	3.2	3.4
Totals			100	100.0	100.0

RANK	Ordered by topic frequency		ESAT 2024	NSAA 2016-23 Section 1	NSAA 2016-22 Section 2
1	A2	16 Inheritance	22.2	19.5	14.7
2	AS	5 The mitotic cell cycle	11.1	7.9	1.0
3	AS	3 Enzymes	7.4	8.4	8.2
4	AS	4 Cell membranes and transport	7.4	6.3	2.4
5	A2	12 Energy and respiration	7.4	5.8	1.0
6	A2	13 Photosynthesis	7.4	5.8	5.5
7	A2	14 Homeostasis	7.4	2.6	1.7
8	AS	1 Cell structure	3.7	5.3	12.6
9	AS	2 Biological molecules	3.7	1.6	0.7
10	AS	6 Nucleic acids and protein synthesis	3.7	7.4	5.5
11	AS	7 Transport in plants	3.7	1.6	2.0
12	AS	8 Transport in mammals	3.7	2.6	6.1
13	A2	17 Selection and evolution	3.7	3.2	9.9
14	A2	18 Classification, biodiversity and conservation	3.7	11.1	22.9
15	A2	19 Genetic technology	3.7	3.2	3.4
16	A2	15 Control and coordination	0.0	4.7	0.3
17	AS	9 Gas exchange	0.0	2.1	0.7
18	AS	11 Immunity	0.0	1.1	0.7
19	AS	10 Infectious diseases	0.0	0.0	0.7
Totals			100	100.0	100.0

AS and A2 CAIE 9701 Chemistry & 9700 Biology analysis

Each exam paper, or combination, like "Papers 1, 2 and 3" use the weighting, as a fraction of the whole A Level (AS and A2 years) given in the syllabus:

Paper	% of AS/A2	% of ALvl	Marks	Time in min	secs/marks	% YEAR	% ALL A-Level/ mark (weighting)
1	31	15.5	40	75	112.5	0.78	0.39
2	46	23.0	60	75	75.0	0.77	0.38
3	23	11.5	40	120	180.0	0.58	0.29
4	77	38.5	100	120	72.0	0.77	0.39
5	23	11.5	30	75	150.0	0.77	0.38

PUM =Percentage Uniform Mark; UMS = Uniform Mark Scale (UK version of PUM)

UMS/PUM allows 2 scores from 2 different versions of the same exam paper that may have been slightly different in terms of difficulty, to be made. A student sitting a slightly harder exam paper will have a lower grade threshold compared to a student, for instance doing their exam papers in a different time zone that is slightly easier. Each grade always has the same UMS score, so an A* is always 90% UMS, but the raw score can be different, often a lower percentage. The table below shows how this threshold has changed in the last 10 years.

Variability in UMS/PUM grade thresholds in CHEMISTRY from 2014s to 2023w

Grade:		A*	A	B	C	D	E
UMS/PUM %		90%	80%	70%	60%	50%	40%
2014s to 2023w	Highest Raw % Score	79	70	62	53	44	35
	Lowest Raw % Score	62	54	46	38	30	21
	Variability	17	16	17	15	14	14
	Average Raw % Score	73	64	55	46	37	29

Grade:		A*	A	B	C	D	E
2020m and before:	Highest Raw % Score	79	70	62	53	44	35
	Lowest Raw % Score	72	63	54	46	37	28
	Variability	7	7	8	7	7	7
	Average Raw % Score	76	67	58	49	41	32

Grade:		A*	A	B	C	D	E
2020w and later:	Highest Raw % Score	74	65	56	46	37	28
	Lowest Raw % Score	62	54	46	38	30	21
	Variability	12	11	10	9	7	7
	Average Raw % Score	69	59	49	41	32	23

Most courses and almost all universities generally do not explain if they use your UMS/PUM score, with the exception of Cambridge, which always requires you to give your UMS/PUM as additional information when you apply, but not through the UCAS form. They have also created and published a report analysing 14,000 applicants dated July 2015:

https://www.cao.cam.ac.uk/sites/www.cao.cam.ac.uk/files/ar_ums_performance_the_destination_of_cambridge_applicants.pdf

The mean average UMS/PUM score for a successful Cambridge applicant was 92% average (for the best 3 AS level subjects), but that average was about 95% for (natural) science applicants, a bar chart using their statistics is provided in this book in the section: *UMS(/PUM) performance and the eventual HE destination of Cambridge applicants*



Unusual material in exam questions

Some of the material, like in the Chemistry NSAA goes slightly beyond the A Level syllabus. Especially

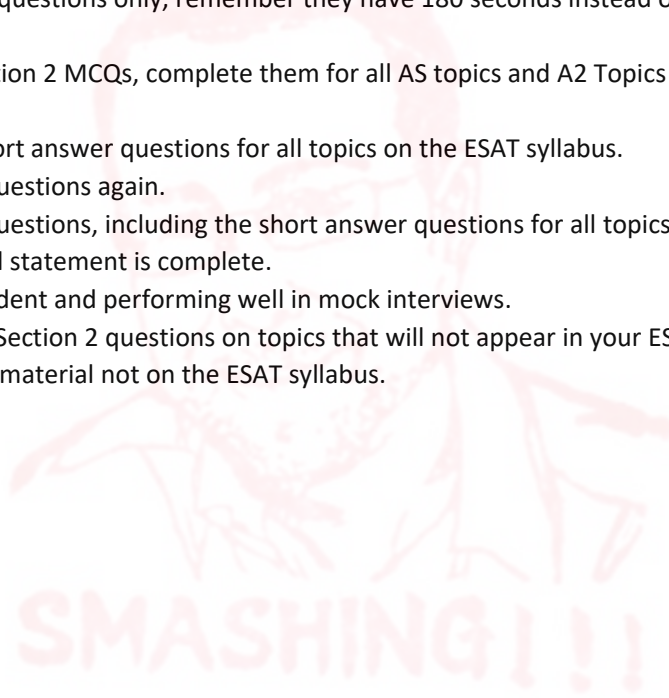
Subject boundaries can also feel blurred, but only in very rare case. For instance, basic **trigonometry** is included with some questions.

Section 1 Questions

The order when you should complete these questions in:

To find IB Higher Level Biology MCQ questions a program called IB Question Bank can help.

1. Get really good at AS (and IB HL) MCQ questions.
2. Then try Section 1 questions, if you are really good at these, continue.
3. If struggling with Section 1 questions, go back and try again to get really good at AS/A2 and IB questions in the same topic.
4. If really good a Section 1 questions, complete all of them.
5. Make sure your personal statement is finished, or nearly finished.
6. Make sure you have started to prepare for the interview by talking in English about biology, ideally with a teacher, and ideally with a teacher who has experience helping students with Oxbridge applications.
7. Then try Section 2 MCQ questions only, remember they have 180 seconds instead of about 90 seconds each.
8. If you really good at Section 2 MCQs, complete them for all AS topics and A2 Topics that are on the ESAT syllabus.
9. Finally, complete the short answer questions for all topics on the ESAT syllabus.
10. Complete all Section 1 questions again.
11. Complete all Section 2 questions, including the short answer questions for all topics on the ESAT syllabus.
12. Make sure your personal statement is complete.
13. Make sure you are confident and performing well in mock interviews.
14. Now you could then try Section 2 questions on topics that will not appear in your ESAT, including the short answer questions on A2 material not on the ESAT syllabus.

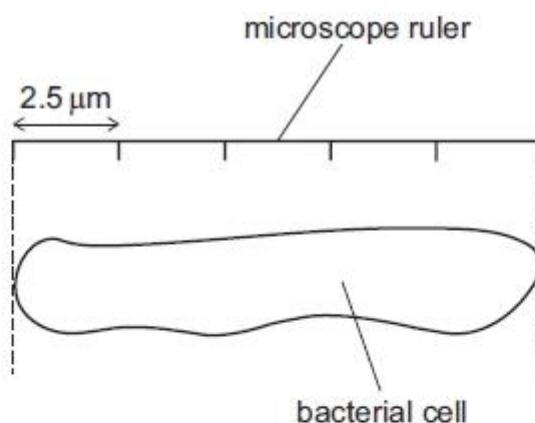


Which of the following cells do not contain mitochondria?

1. bacterial cells
 2. embryonic stem cells
 3. mature red blood cells
 4. potato cells
-
- ☐ 1 only
 - ☐ 2 only
 - ☐ 3 only
 - ☐ 4 only
 - ☐ 1 and 2 only
 - ☐ 1 and 3 only
 - ☐ 1 and 4 only
 - ☐ 2 and 4 only



- 67 A student viewed a bacterial cell using a microscope. The cell was measured with a microscope ruler as shown in the diagram. Each division on this ruler measures $2.5\mu\text{m}$.



The student made a drawing of this cell. The drawing was 5.0 cm in length and included the structures that the student expected to see.

Which row of the table gives the magnification of the student's drawing and one of the structures that should be included?

	<i>magnification of the student's drawing</i>	<i>structure that should be included</i>
A	2.5×10^{-4}	cell wall
B	2.5×10^{-4}	nucleus
C	4.0×10^{-1}	cell wall
D	4.0×10^{-1}	nucleus
E	4.0×10^3	cell wall
F	4.0×10^3	nucleus
G	2.0×10^4	cell wall
H	2.0×10^4	nucleus

73 Two different cells, cell L and cell M, were studied using a microscope and then drawn. The drawings are not shown.

Some of the data collected is shown in the table.

	cell L	cell M
<i>actual maximum length of cell / μm</i>	400	40
<i>maximum length of cell in drawing / cm</i>	2	1

Which of the following statements is/are correct?

- 1 Cell L has been magnified 50 times.
- 2 Cell M has been magnified 5 times as much as cell L.
- 3 Both cells could have a cell wall.

A none of them

B 1 only

C 2 only

D 3 only

E 1 and 2 only

F 1 and 3 only

G 2 and 3 only

H 1, 2 and 3

62 A particular cell has the following features:

- a cell wall
- a cell membrane
- no mitochondria

Which of the following statements about this cell is correct?

A It may be an animal cell.

B It may have no nucleus.

C It may contain chloroplasts.

D It contains X and Y chromosomes.

E It is not able to respire.

62 Which of the following cells do not contain mitochondria?

- 1 bacterial cells
- 2 embryonic stem cells
- 3 mature red blood cells
- 4 potato cells

- A 1 only
- B 2 only
- C 3 only
- D 4 only
- E 1 and 2 only
- F 1 and 3 only
- G 1 and 4 only
- H 2 and 4 only

64 Bacteria reproduce asexually by dividing into two by binary fission.

Which of the following statements is/are correct about binary fission in bacteria?

- 1 As it is a form of asexual reproduction, there cannot be any variation in the offspring.
- 2 It can lead to a repeated doubling in population size if there are no limiting factors.
- 3 If binary fission occurs every 20 minutes, one bacterium would become 72^2 bacteria in 24 hours.

- A none of them
- B 1 only
- C 2 only
- D 3 only
- E 1 and 2 only
- F 1 and 3 only
- G 2 and 3 only
- H 1, 2 and 3

55 Which of the following statements is/are correct for both bacterial cells and sperm cells?

- 1 The cell can divide.
- 2 The cell contains DNA.
- 3 The cell has a cell wall.
- 4 The cell has a nucleus.
- 5 The cell can carry out respiration.

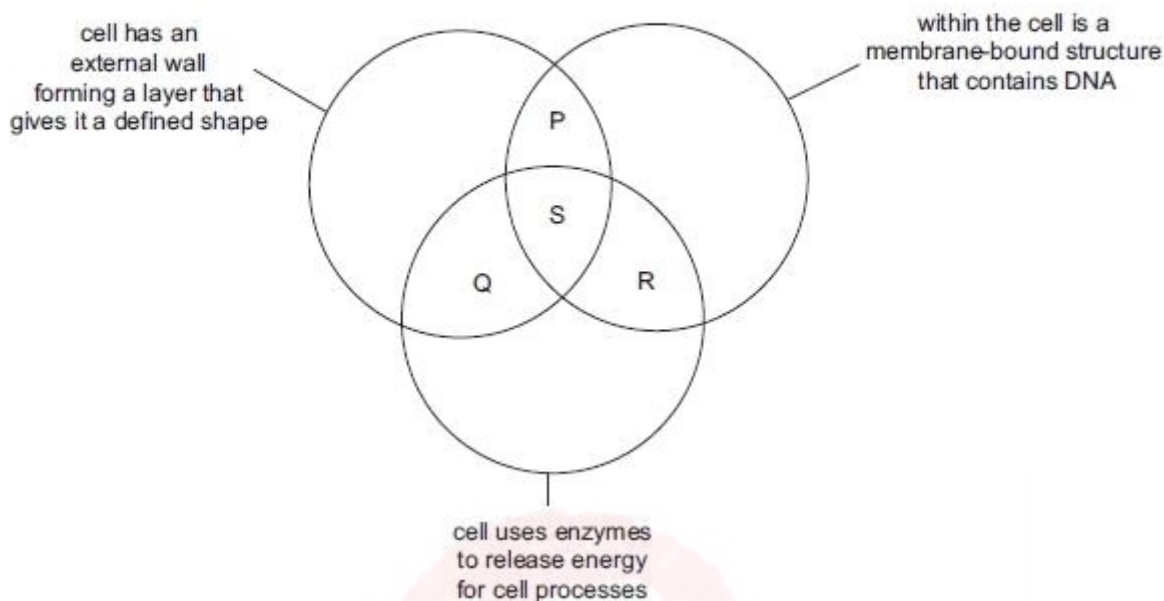
- A 2 only
B 4 only
C 1 and 2 only
D 2 and 5 only
E 3 and 4 only
F 3 and 5 only
G 1, 2 and 5 only
H 1, 3 and 4 only

62 Which of the following statements about bacterial cell division is/are correct?

- 1 Daughter cells show a large degree of genetic difference to the parent cell.
- 2 After each division, two daughter cells are produced by mitosis.
- 3 Chromosome replication occurs in the cytoplasm of the bacteria.

- A none of them
B 1 only
C 2 only
D 3 only
E 1 and 2 only
F 1 and 3 only
G 2 and 3 only
H 1, 2 and 3

60 The diagram shows three features which are used to group organisms.



Fungi, bacteria and animals can each be placed in one of the regions labelled P, Q, R or S on the diagram.

Which row in the following table is correct?

	<i>fungi</i>	<i>bacteria</i>	<i>animals</i>
A	P	S	R
B	P	R	S
C	Q	R	P
D	S	Q	R
E	S	S	S
F	R	P	Q
G	R	Q	P

- 62** A student used a light microscope at a magnification of 40x to observe a slide of a stained non-dividing tissue. In the cells of this tissue, the student noted the presence of a large central vacuole and cytoplasm containing a single, stained, round structure.

Which of the following structures, if any, might the student also have seen in this tissue at this magnification?

- 1 cell wall
 - 2 mitochondria
 - 3 chromosomes
-
- A none of them
 - B 1 only
 - C 2 only
 - D 3 only
 - E 1 and 2 only
 - F 1 and 3 only
 - G 2 and 3 only
 - H 1, 2 and 3

- 57** A student described a population of organisms as having the following features

- 1 single celled
- 2 chloroplasts present
- 3 cell wall present

Using this information, which type of organism could this describe?

- A algae
- B bacteria
- C ferns
- D fungi
- E flowering plants

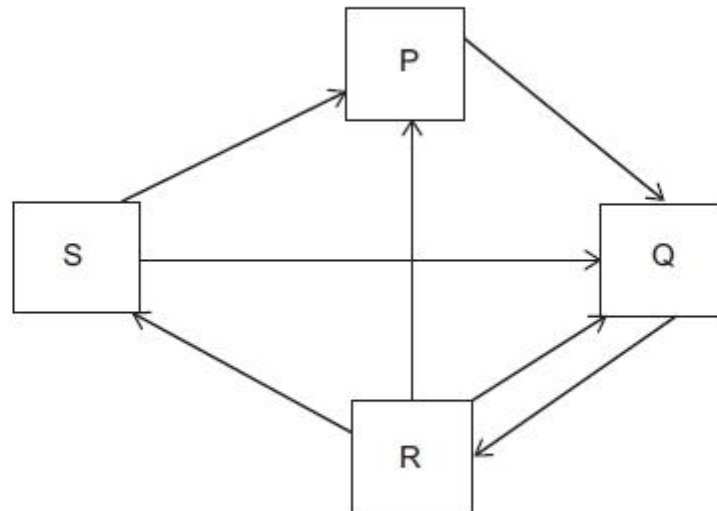
Which of the following could be found in an adult liver cell?

1. starch
 2. at least one X chromosome
 3. gene for amylase
-
- ☐ none of them
- ☐ 1 only
- ☐ 2 only
- ☐ 3 only
- ☐ 1 and 2 only
- ☐ 1 and 3 only
- ☐ 2 and 3 only
- ☐ 1, 2 and 3

Topic 2 Q# 13/ Cambridge/2020sp/Section 1/ Biology NSAA/ Q# 79 /www.SmashingScience.org/
79 Which of the following could be found in an adult liver cell?

- 1 starch
 - 2 at least one X chromosome
 - 3 gene for amylase
-
- A none of them
- B 1 only
- C 2 only
- D 3 only
- E 1 and 2 only
- F 1 and 3 only
- G 2 and 3 only
- H 1, 2 and 3

64 The diagram shows part of the carbon cycle.



Which row identifies the correct descriptions for boxes P, Q, R and S?

	<i>CO₂ in atmosphere</i>	<i>carbon-rich compounds in animals</i>	<i>carbon-rich compounds in decomposers</i>	<i>carbon-rich compounds in plants</i>
A	P	Q	R	S
B	Q	P	S	R
C	S	Q	R	P
D	Q	S	P	R
E	S	R	Q	P
F	R	S	P	Q
G	P	R	Q	S
H	R	P	S	Q

- 64** In an investigation, a molecule of DNA was extracted and separated into its single strands 1 and 2. The percentage of each base present in each strand was found.

The table shows some of the results for strand 1.

DNA sample	base present (%)			
	adenine [A]	cytosine [C]	guanine [G]	thymine [T]
strand 1	26	?	28	14

P, Q, R and S are the percentages of each base in the complementary strand 2.

DNA sample	base present (%)			
	adenine [A]	cytosine [C]	guanine [G]	thymine [T]
strand 2	P	Q	R	S

A student calculates the following percentages for P, Q, R and S:

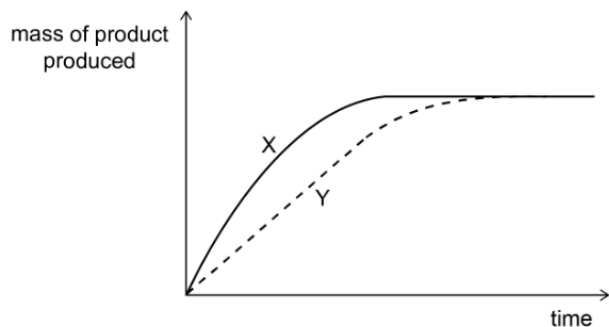
P 14%
Q 28%
R 26%
S 28%

Which of the percentages is/are correct?

- A P only
- B Q only
- C R only
- D S only
- E P and Q only
- F R and S only



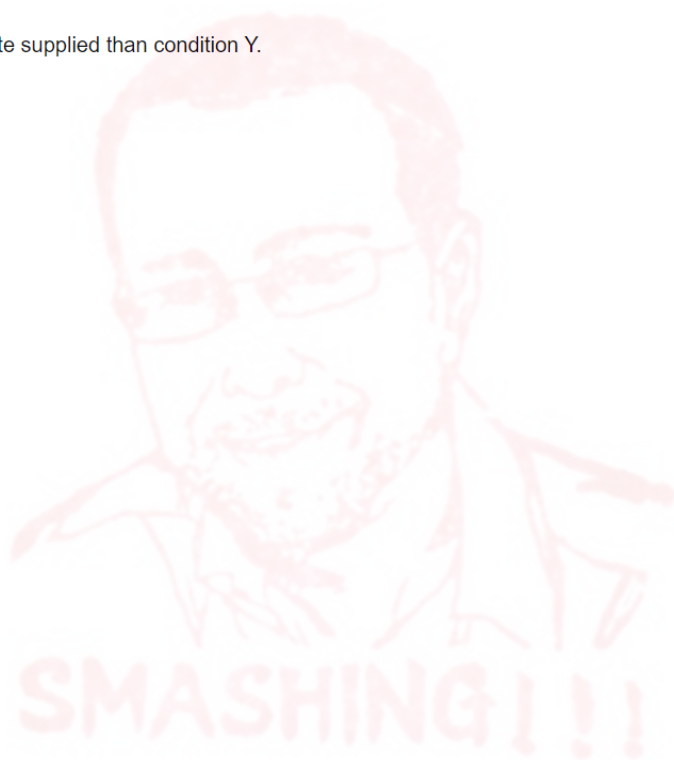
The graph shows the mass of product produced over time for an enzyme-controlled reaction in two different conditions, X and Y. All other variables were kept constant.



Which of the following could be correct for this graph?

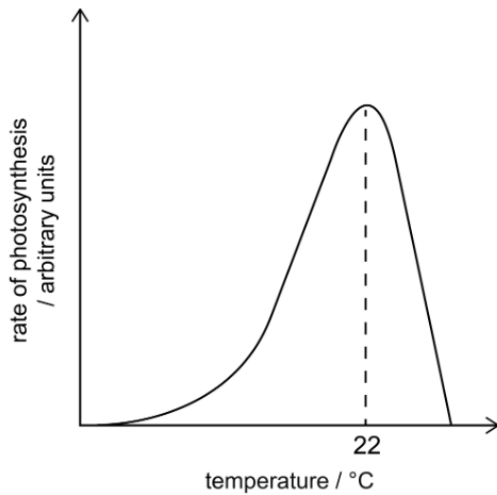
1. Condition X is a higher pH than condition Y.
2. Condition X has less substrate supplied than condition Y.
3. Condition X is a lower pH than condition Y.
4. Condition X has more substrate supplied than condition Y.

- ☐ none of them
- ☐ 1 and 2 only
- ☐ 1 and 3 only
- ☐ 1 and 4 only
- ☐ 2 and 3 only
- ☐ 2 and 4 only
- ☐ 3 and 4 only
- ☐ 1, 2, 3 and 4



A student carried out an experiment to investigate the effect of temperature on the rate of photosynthesis. All of the other variables were kept constant.

The graph shows the results obtained.



The student considered the graph and made the following conclusions.

1. Up to 22 °C temperature is limiting the rate of photosynthesis.
2. At temperatures higher than 22 °C not all of the enzymes work so the rate of photosynthesis drops.
3. As the temperature increases across the temperature range studied, the rate of photosynthesis increases due to increased kinetic energy.

Which of the student's conclusions is/are correct?

- ☐ none of them
- ☐ 1 only
- ☐ 2 only
- ☐ 3 only
- ☐ 1 and 2 only
- ☐ 1 and 3 only
- ☐ 2 and 3 only
- ☐ 1, 2 and 3

71 A scientist was investigating the effect of substrate concentration on lipase enzyme activity

Two test tubes were set up:

- one containing a sample of full-fat milk mixed with an alkaline solution, and a pH indicator
- one containing lipase

The pH indicator turned the alkaline milk sample pink.

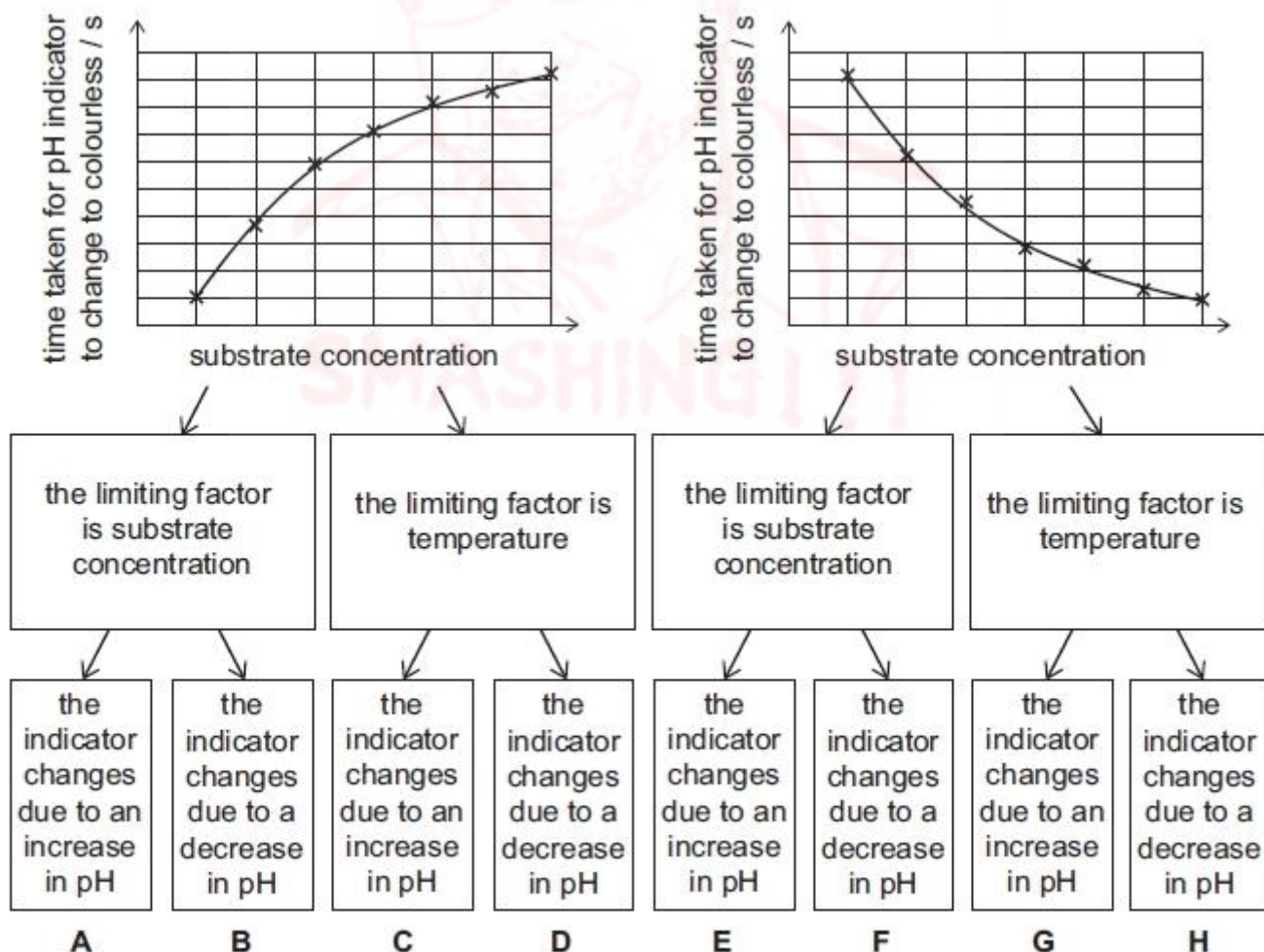
Both tubes were incubated in a water bath set to an optimum temperature for lipase until the contents had reached this temperature.

The scientist then added the lipase to the tube with the milk sample and measured the time taken for the indicator to turn colourless. This colour change was caused by an increase in concentration of one of the products of the reaction.

Further samples of the milk were diluted, and added to the same quantity of alkaline solution and pH indicator, to produce another six different substrate concentrations, and the experiment was repeated. All other variables were kept constant.

The scientist found that each substrate concentration caused the pH indicator to change to colourless in a different length of time. The results of the reaction in all seven tubes were plotted on a graph.

Which option correctly identifies the shape of the graph of the results, the limiting factor during the experiment and an explanation for the change in colour of the pH indicator?

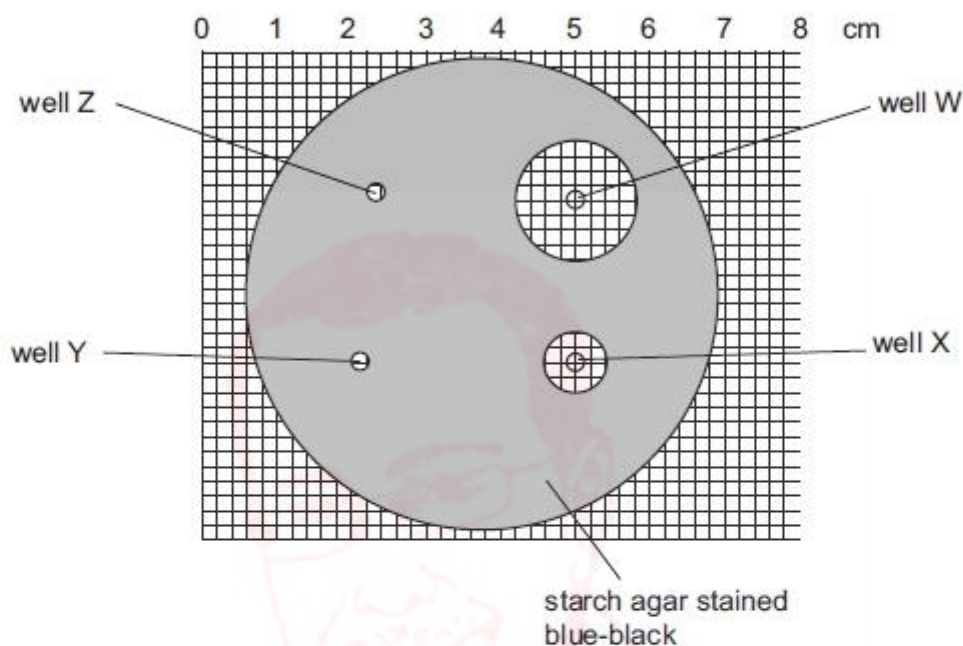


64 A Petri dish was filled with agar that had been mixed with starch. The agar is not digested by enzymes used in the experiment.

Four small wells were cut in the agar. Three were filled with different solutions. Well Y was filled with water to act as a control.

The dish was kept at 30°C for 30 minutes. The surface of the agar was then washed with iodine solution, turning parts of it blue-black in the presence of starch.

The Petri dish was placed on a piece of graph paper, as shown in the diagram, to measure the clear areas around the wells. The area of each well should be considered negligible.



Which of the statements is/are correct?

- 1 The area of starch digested around well W is 4 times the area digested around well X.
- 2 Amylase could have been used in well W and protease could have been used in well X.
- 3 The solution put in well Z could have contained boiled enzyme.

- A none of them
- B 1 only
- C 2 only
- D 3 only
- E 1 and 2 only
- F 1 and 3 only
- G 2 and 3 only
- H 1, 2 and 3

74 An investigation was carried out to study the effect of protease concentration on the rate of breakdown of a protein into amino acids.

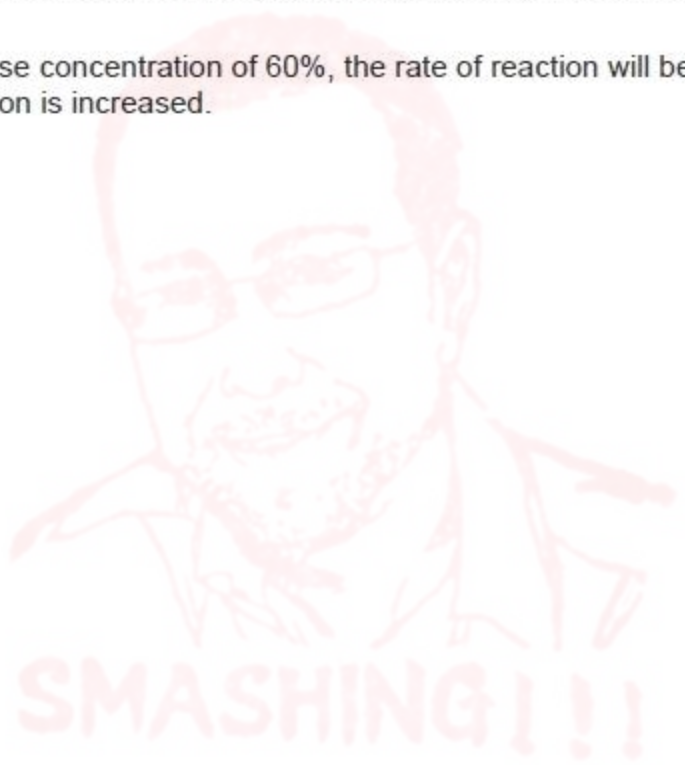
A protease solution of known concentration was diluted and used in each experiment, and all other variables were kept constant. The table shows the results.

<i>percentage concentration of protease</i>	10	20	30	40	50	60	70
<i>rate of reaction / arbitrary units</i>	1.8	3.5	5.3	6.0	6.3	6.3	6.3

Which of the following statements is/are correct about this investigation?

- 1 Between concentrations of 10% and 40%, the rate of reaction has increased as more active sites are available.
- 2 Between concentrations of 50% and 70%, the enzyme concentration is the limiting factor.
- 3 At a protease concentration of 60%, the rate of reaction will be faster if substrate concentration is increased.

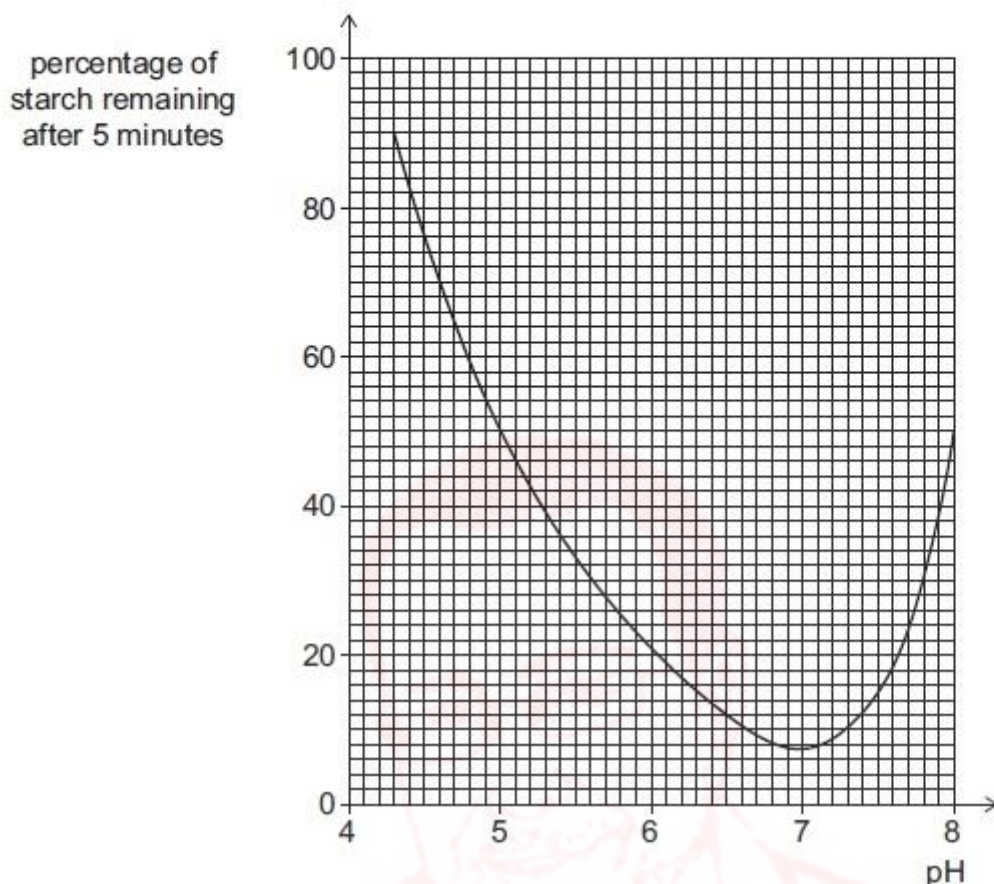
- A none of them
- B 1 only
- C 2 only
- D 3 only
- E 1 and 2 only
- F 1 and 3 only
- G 2 and 3 only
- H 1, 2 and 3



71 The effect of pH on the breakdown of starch by pancreatic amylase was investigated.

Starch and pancreatic amylase solution were mixed in test tubes, each at a different pH. The percentage of starch remaining after 5 minutes was recorded on the graph.

All other variables were kept constant.



Using these results, which of the following conclusions could be correct?

- 1 During the 5 minutes, there are more enzyme–product complexes formed at pH 4.5 than at pH 6.
- 2 The shape of the enzyme is different at pH 5 compared to the shape at pH 7.
- 3 The optimum pH for this enzyme is approximately pH 7 under the conditions of this experiment.

- A none of them
- B 1 only
- C 2 only
- D 3 only
- E 1 and 2 only
- F 1 and 3 only
- G 2 and 3 only
- H 1, 2 and 3

- 76** A fungus feeds by releasing amylase onto starchy food. The soluble products of the breakdown of starch are absorbed by the fungus.

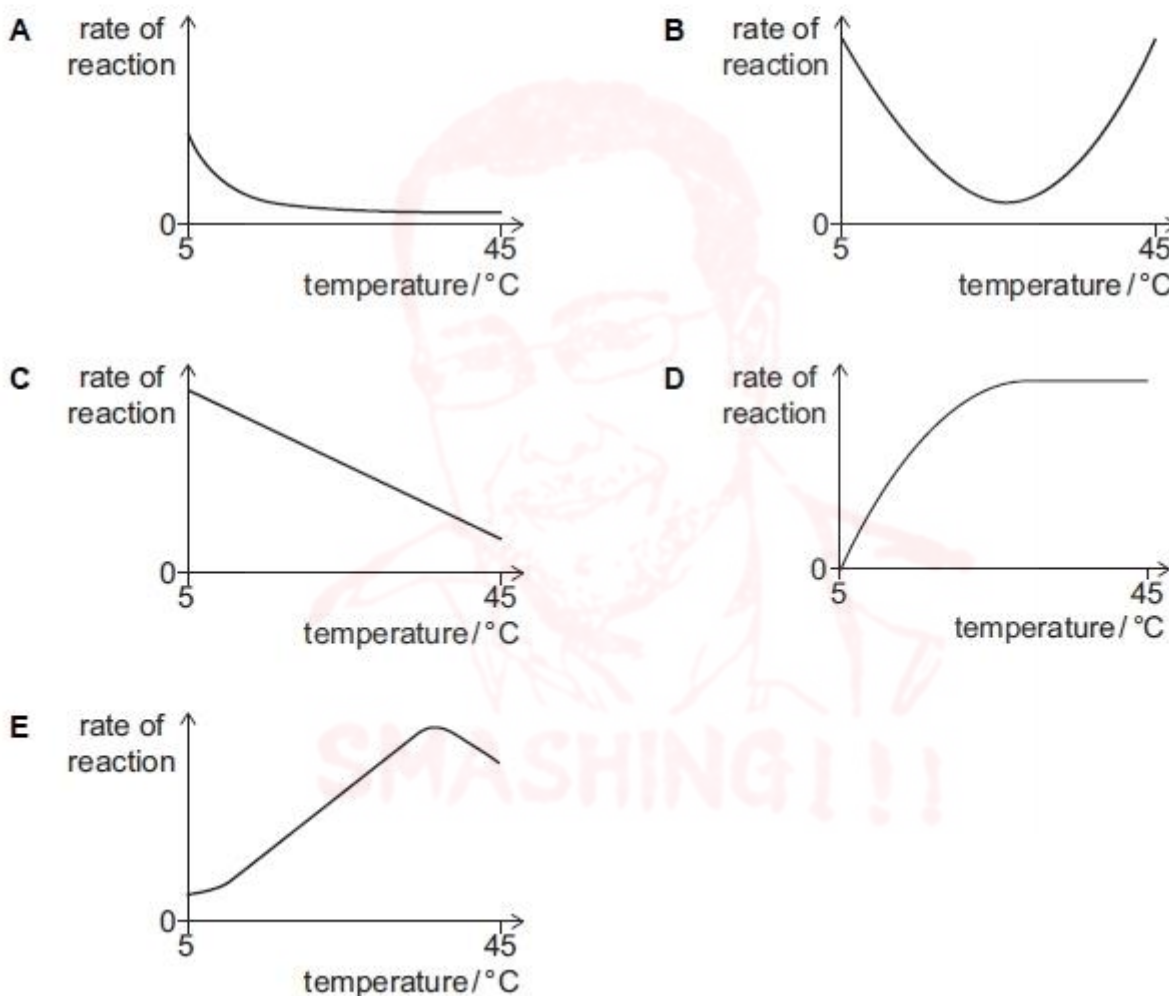
Test tubes were set up containing a mixture of starch solution and fungus. Each test tube was maintained at a different temperature between 5 °C and 45 °C.

Samples of the mixture were removed early in the experiments to determine the initial rates of this enzyme-catalysed reaction.

The results were plotted.

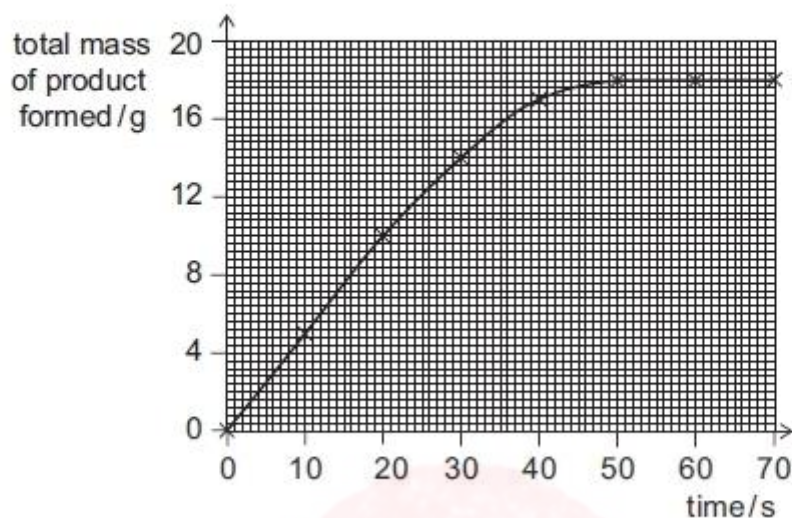
All of the other variables were kept constant.

Which graph shows the expected results?



67 An enzyme-catalysed reaction was studied and the mass of product formed was measured over time.

The results are shown in the graph.



Which of the following statements is/are correct?

- 1 The enzymes may have been used up in the reaction.
- 2 The initial rate of reaction is 120 g min^{-1} .
- 3 At high concentrations, the product formed may inhibit the enzymes.

- A none of them
- B 1 only
- C 2 only
- D 3 only
- E 1 and 2 only
- F 1 and 3 only
- G 2 and 3 only
- H 1, 2 and 3

77 Catalase is an enzyme found inside plant and animal cells. When catalase is added to hydrogen peroxide, bubbles of oxygen gas are formed.

Red blood cells were placed into either water or plasma, and were placed in the dark.

Plant cells were placed into either water or 0.5 mol dm^{-3} sucrose solution, and were placed in the dark.

Assume that hydrogen peroxide and catalase do not cross the cell surface membrane.

Which row shows the results when hydrogen peroxide was added?

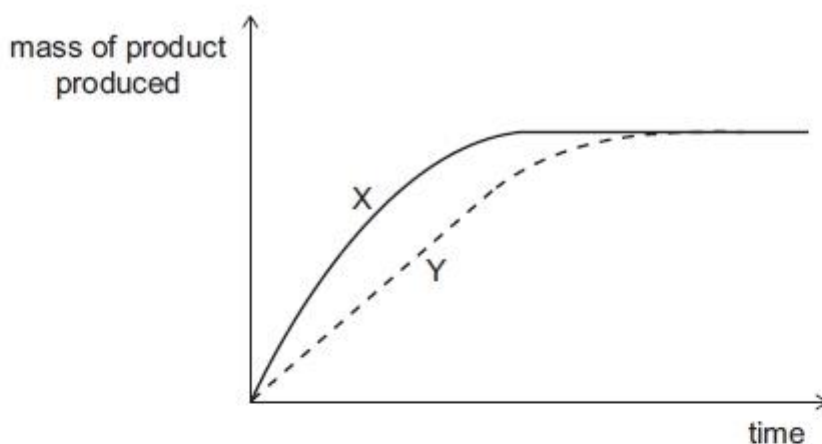
Key

✓ = oxygen bubbles will form

x = oxygen bubbles will not form

	when hydrogen peroxide was added to			
	red blood cells in plasma	plant cells in a 0.5 mol dm^{-3} sucrose solution	red blood cells in water	plant cells in water
A	✓	✓	x	x
B	x	x	✓	✓
C	x	x	✓	x
D	x	x	x	✓
E	✓	✓	✓	x
F	✓	✓	x	✓

72 The graph shows the mass of product produced over time for an enzyme-controlled reaction in two different conditions, X and Y. All other variables were kept constant.



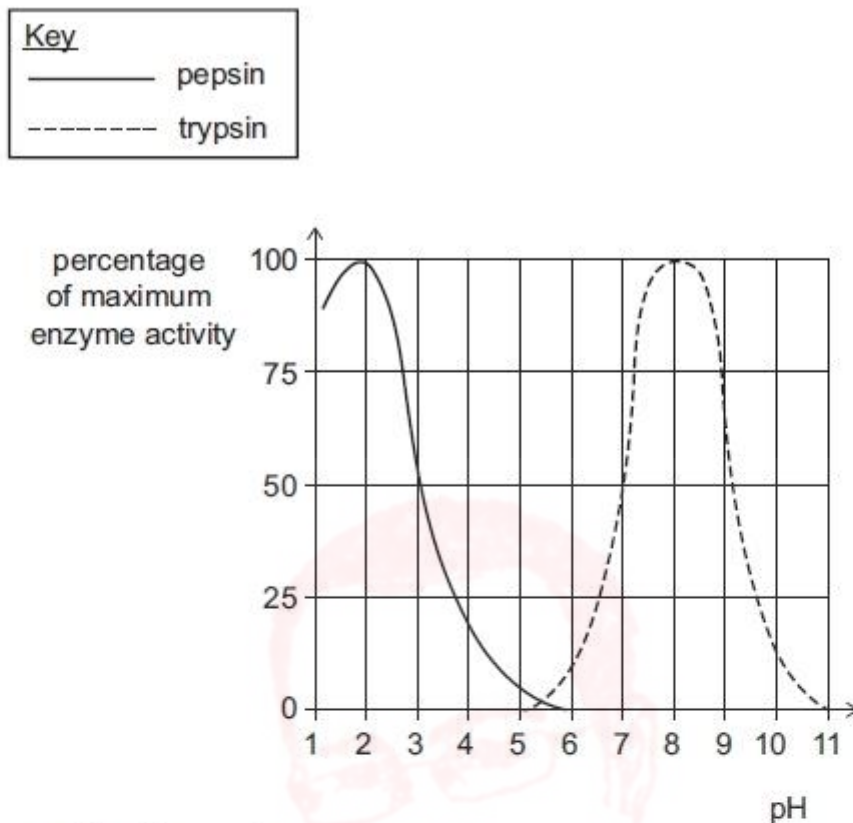
Which of the following could be correct for this graph?

- 1 Condition X is a higher pH than condition Y.
- 2 Condition X has less substrate supplied than condition Y.
- 3 Condition X is a lower pH than condition Y.
- 4 Condition X has more substrate supplied than condition Y.

- A none of them
- B 1 and 2 only
- C 1 and 3 only
- D 1 and 4 only
- E 2 and 3 only
- F 2 and 4 only
- G 3 and 4 only
- H 1, 2, 3 and 4

66 Pepsin and trypsin are both protease enzymes found in the human digestive system.

The graph shows how the activity of both enzymes varies with pH.



In the human digestive system:

- 1 pepsin is most active in the stomach.
- 2 trypsin would be inactive in the stomach.
- 3 pepsin could be a substrate for trypsin.
- 4 pepsin is most active at low acidity and trypsin most active at high acidity.

Which statements are correct?

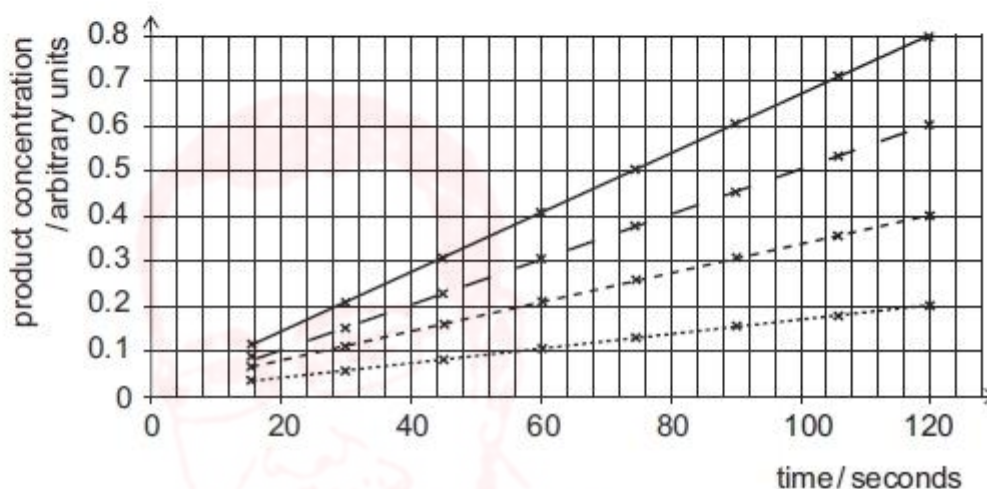
- A 1 and 2 only
- B 1 and 3 only
- C 1 and 4 only
- D 2 and 3 only
- E 2 and 4 only
- F 3 and 4 only
- G 1, 2 and 3 only
- H 2, 3 and 4 only

71 An investigation was carried out on the effect of substrate concentration on an enzyme-controlled reaction.

Four different concentrations of substrate were tested. In each case, the concentration of product was measured at regular intervals following the introduction of the substrate.

All the other variables were kept constant.

The results obtained are shown on the graph.



Which of the following statements is/are correct?

- 1 As substrate concentration increases, the time taken to produce 0.2 arbitrary units of product increases.
- 2 Doubling the substrate concentration always doubles the rate of the reaction.
- 3 The average rate of reaction for a substrate concentration of 1.0 mmol dm⁻³ is 0.005 arbitrary units per second.

- A none of them
- B 1 only
- C 2 only
- D 3 only
- E 1 and 2 only
- F 1 and 3 only
- G 2 and 3 only
- H 1, 2 and 3

67 Phosphatase enzymes break the bond between a phosphate group and the rest of a molecule.

Phenolphthalein phosphate (PPP) is colourless and is a substrate for phosphatase enzymes.

- The phosphate group of PPP can be removed by the phosphatase enzyme to produce the indicator phenolphthalein.
- Phenolphthalein goes pink in alkaline conditions.

Five tubes were set up with equal concentrations of PPP and a plant phosphatase enzyme.

Each tube was at a different pH. The tubes were incubated at the same temperature. After 10 minutes Na_2CO_3 was then added to each tube until a pH of 9.5 was reached. The colour was observed immediately and then again after another 5 minutes.

tube	1	2	3	4	5
<i>pH of the initial reaction</i>	3.2	4.2	5.2	8.2	9.2
<i>colour immediately after Na_2CO_3 addition</i>	pale pink	pink	dark pink	colourless	colourless
<i>colour after another 5 minutes</i>	pale pink	pink	dark pink	colourless	colourless

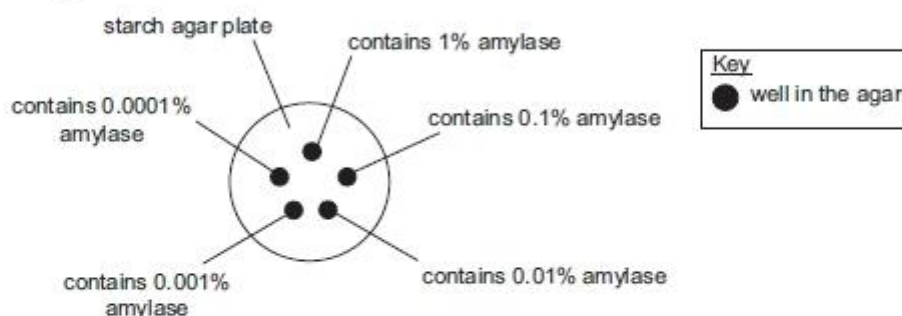
Which of the following statements is/are correct?

- 1 Na_2CO_3 solution inhibited the activity of the phosphatase enzyme.
- 2 More substrate was produced in conditions of high acidity compared to low acidity.
- 3 The optimum pH for this plant phosphatase must be 5.2.

- A none of them
- B 1 only
- C 2 only
- D 3 only
- E 1 and 2 only
- F 1 and 3 only
- G 2 and 3 only
- H 1, 2 and 3

- 68 A student carried out an experiment to investigate the effect of enzyme concentration on the rate of an enzyme-controlled reaction.

The student used a starch agar plate with five identically sized small wells cut into the agar. The wells were filled with identical volumes of different concentrations of amylase solution, as shown in the diagram.



The starch agar plate was incubated overnight and the plate was then flooded with iodine solution. Most of the agar stained blue, but there was a clear area around each well where starch had been digested by the amylase. The student measured and recorded the diameter of the clear area that formed. The results are shown in the table below.

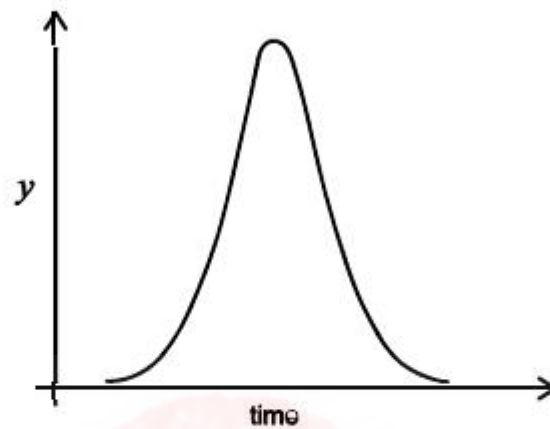
<i>percentage concentration of amylase</i>	<i>diameter of clear area that forms around the well containing amylase / mm</i>
1.0	27
0.1	24
0.01	15
0.001	12
0.0001	9

Which of the following factors **could** have affected the diameter of the clear area around the wells containing amylase?

- 1 pH of the starch agar
 - 2 concentration of the amylase solution
 - 3 temperature at which the plates were incubated
- A none of them
 B 1 only
 C 2 only
 D 3 only
 E 1 and 2 only
 F 1 and 3 only
 G 2 and 3 only
 H 1, 2 and 3

68 A student carried out an experiment on an enzyme-catalysed reaction using amylase. The amylase was added to the substrate and left to react.

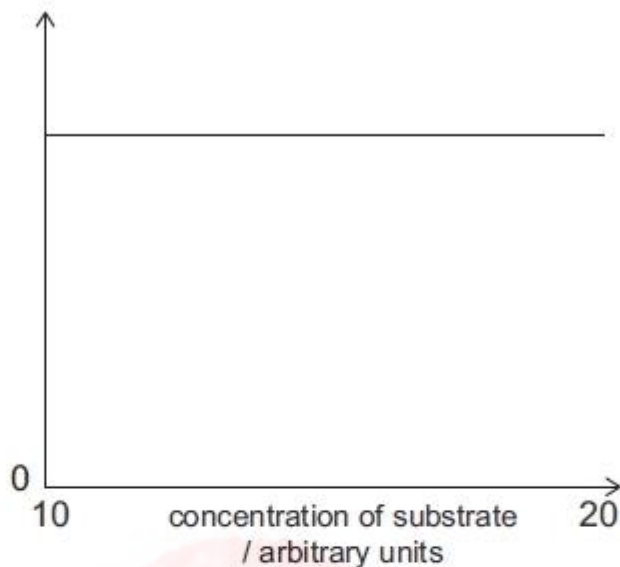
The graph shows the results of this experiment.



What should the label be on the y-axis?

- A enzyme concentration
- B enzyme-substrate complex concentration
- C pH
- D product concentration
- E substrate concentration

71 The graph shows the effect of increasing the substrate concentration on an enzyme-controlled reaction when all the other variables were kept constant.

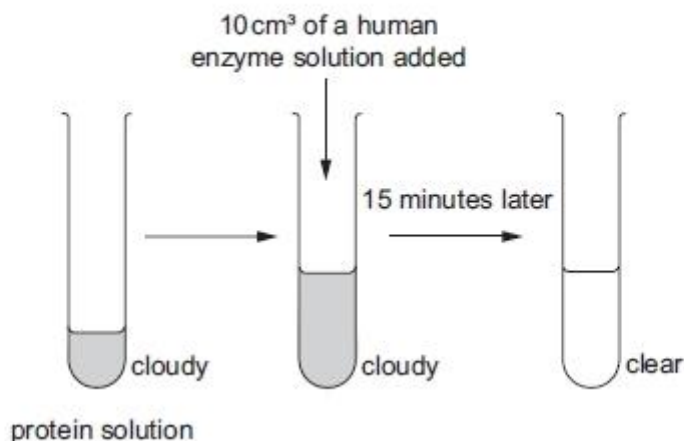


Which of the following labels, if any, could be correct for the y-axis?

- 1 rate of substrate loss / mg min^{-1}
- 2 rate of enzyme-substrate complex formation / number of complexes s^{-1}
- 3 rate of product formed per enzyme molecule / mg min^{-1}

- A none of them
- B 1 only
- C 2 only
- D 3 only
- E 1 and 2 only
- F 1 and 3 only
- G 2 and 3 only
- H 1, 2 and 3

60 A student set up the following apparatus at a temperature of 25 °C and at pH 7.

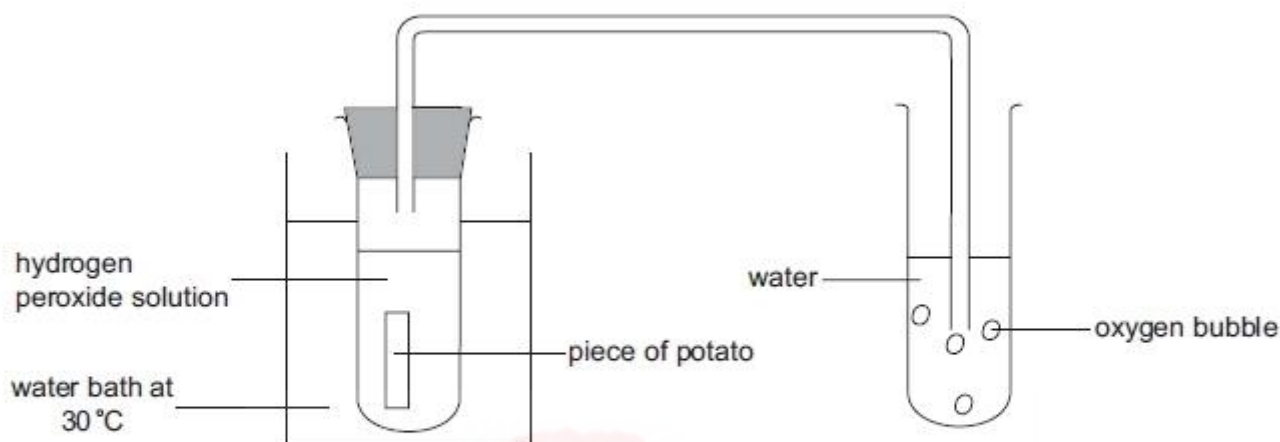


What could the student change so that it would take less than 15 minutes for the solution to become clear?

- A Carry out the experiment at pH 7, but increase the temperature to 70 °C.
- B Carry out the experiment, stirring the mixture once every 30 seconds.
- C Carry out the experiment at a temperature of 25 °C and a pH of 13.
- D Double the volume of both the protein solution and the enzyme solution.
- E Halve the volume of both the protein solution and the enzyme solution.

- 58** A student carried out an experiment to investigate how temperature affects the rate of activity of an enzyme found in potatoes. This enzyme breaks down the substrate hydrogen peroxide to produce water and oxygen.

The apparatus was set up as shown in the diagram and the experiment carried out at 30 °C.



The student counted the number of bubbles of oxygen produced in one minute.

The experiment was repeated at 40 °C, 50 °C, 60 °C, and 70 °C.

The table shows the results collected by the student.

<i>temperature / °C</i>	<i>number of bubbles of oxygen gas produced in one minute</i>
30	32
40	27
50	23
60	8
70	2

A group of students were given these results and asked to calculate the percentage decrease in the number of bubbles produced between 30 °C and 60 °C. Each student was also asked to write a conclusion to explain the results. These are shown in the table below.

Which student correctly calculated the percentage decrease in the number of bubbles between 30 °C and 60 °C and wrote an appropriate conclusion which explains the reason for this decrease?

	<i>percentage decrease in the number of bubbles between 30 °C and 60 °C</i>	<i>conclusion</i>
A	20	the high temperature causes the bonds maintaining the structure of the enzyme to break
B	20	the temperature of the environment is too hot and the enzyme dies
C	75	the high temperature causes the bonds maintaining the structure of the enzyme to break
D	75	the temperature of the environment is too hot and the enzyme dies
E	300	the high temperature causes the bonds maintaining the structure of the enzyme to break
F	300	the temperature of the environment is too hot and the enzyme dies

An animal cell is surrounded by a very dilute glucose solution which has a lower concentration of glucose than the glucose solution in the cytoplasm of the cell. There is net movement of glucose molecules and water molecules into the cell.

A second, identical cell is treated for a short time with a chemical which inhibits respiration. The cell is then surrounded by the same glucose solution.

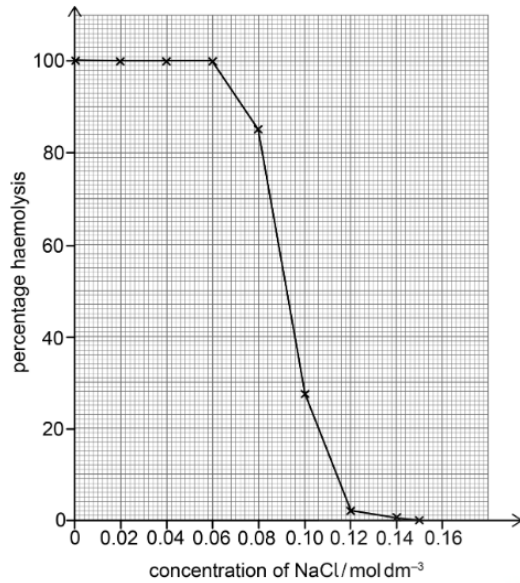
Which row in the table shows the effect of this chemical on the movement of glucose molecules into the cell and the movement of water molecules across the cell surface membrane immediately after it is surrounded by the solution?

	<i>net movement of glucose molecules</i>	<i>net movement of water molecules</i>
A	do not move into the cell	move into the cell
B	move into the cell	move into the cell
C	do not move into the cell	no net movement into or out of the cell
D	move into the cell	no net movement into or out of the cell
E	do not move into the cell	move out of the cell
F	move into the cell	move out of the cell

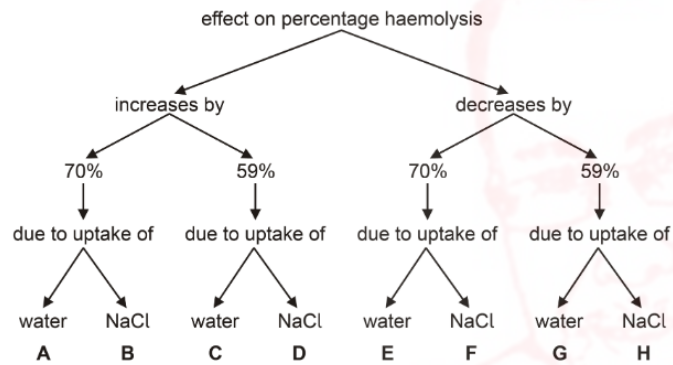
- ☐ A
- ☐ B
- ☐ C
- ☐ D
- ☐ E
- ☐ F



The graph below shows the effect of different concentrations of sodium chloride (NaCl) solution on the percentage haemolysis of human red blood cells. Haemolysis occurs when the cells swell and then burst open.



Which letter correctly describes the effect of changing the concentration of NaCl from 0.12 mol dm⁻³ to 0.084 mol dm⁻³ on percentage haemolysis?

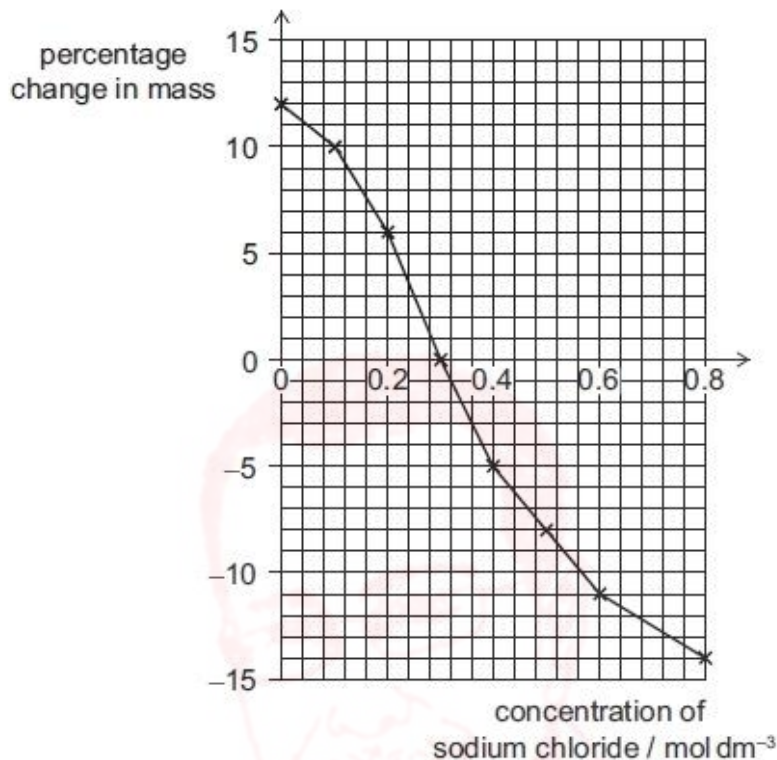


- ☐ A
- ☐ B
- ☐ C
- ☐ D
- ☐ E
- ☐ F
- ☐ G
- ☐ H

74 In an experiment, 8 identical cubes of potato were each weighed and placed in a different test tube.

Each of the test tubes contained a different concentration of sodium chloride solution. All other conditions were kept the same throughout the experiment.

After 30 minutes, the potato cubes were removed from the test tubes and weighed, and the percentage change in mass was calculated.

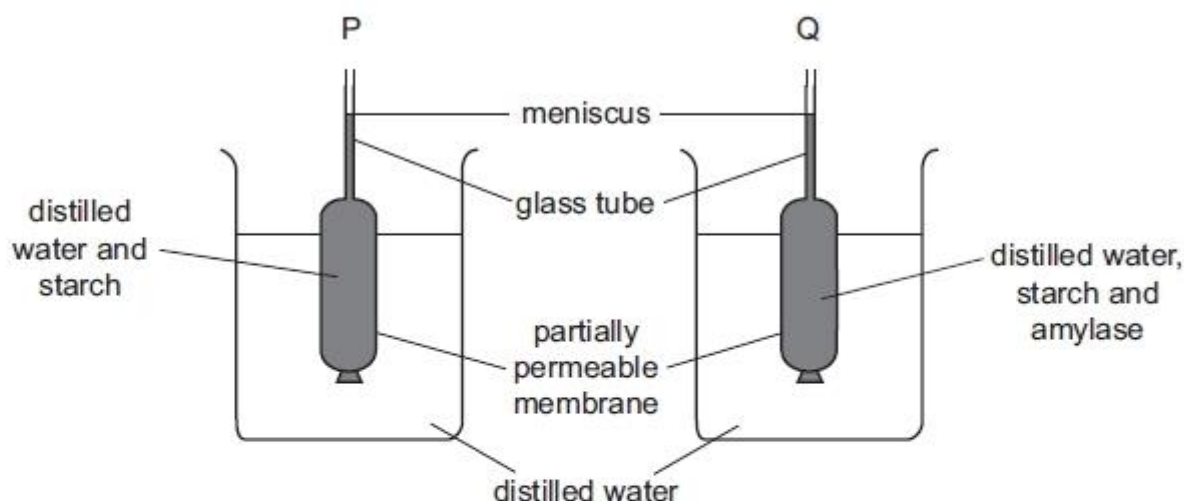


Which of the following statements is/are correct?

- 1 The initial concentration of sodium chloride inside the potato cubes must be 0.3 mol dm^{-3} .
- 2 Osmosis involves the diffusion of water molecules from a solution of high solute concentration to one of low solute concentration.
- 3 In this experiment, the rate of osmosis is fastest at a sodium chloride concentration of 0.8 mol dm^{-3} .

- A none of them
- B 1 only
- C 2 only
- D 3 only
- E 1 and 2 only
- F 1 and 3 only
- G 2 and 3 only
- H 1, 2 and 3

76 The diagram shows two sets of apparatus, P and Q, at the beginning of an investigation.



The only difference between P and Q was the contents of the partially permeable membrane.

The membrane is not permeable to starch or amylase but is permeable to smaller molecules.

After 10 minutes:

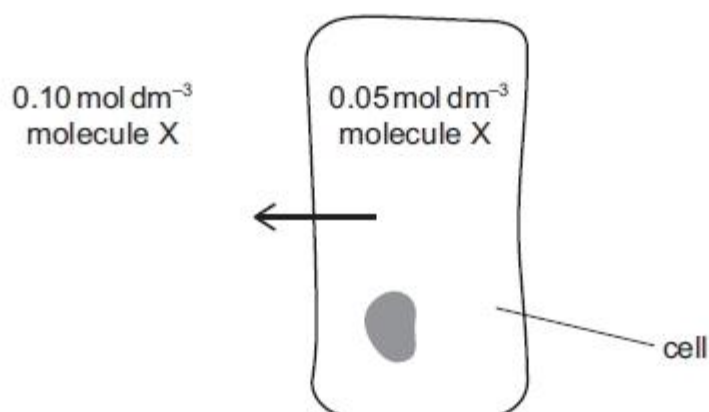
- the position of the meniscus in P had moved up the tube,
- the position of the meniscus in Q had moved down the tube.

Which of the following statements correctly explain(s) these observations?

- 1 Water moved by osmosis in P and Q.
- 2 Amylase was a substrate for starch.
- 3 Maltose was diffusing across the partially permeable membrane in Q, but not in P.

- A none of them
- B 1 only
- C 2 only
- D 3 only
- E 1 and 2 only
- F 1 and 3 only
- G 2 and 3 only
- H 1, 2 and 3

- 63 The arrow in the diagram shows the net movement of molecule X out of a healthy mammalian cell.



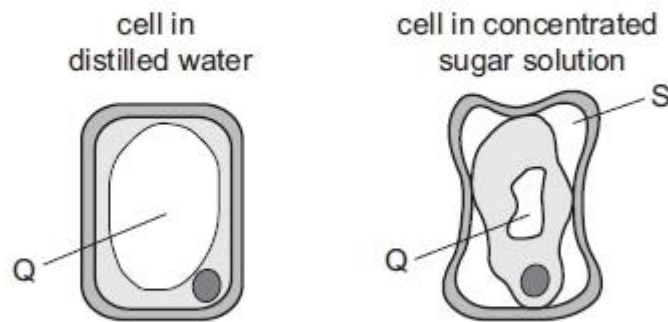
The maximum cell width is $10 \mu\text{m}$. The cell membrane accounts for 0.2% of this width.

What is the width of a single cell membrane, in nm, and which process is represented by the arrow in the diagram?

	<i>width of a single cell membrane / nm</i>	<i>process represented by the arrow in the diagram</i>
A	0.01	diffusion
B	0.01	active transport
C	0.02	diffusion
D	0.02	active transport
E	10	diffusion
F	10	active transport
G	20	diffusion
H	20	active transport

- 71** Two identical plant cells were removed from a leaf. One was placed in a concentrated sugar solution and the other was placed in distilled water, and both were left for 2 hours.

All other factors were kept constant during the experiment. The diagram shows the results, with regions of each cell labelled Q and S.



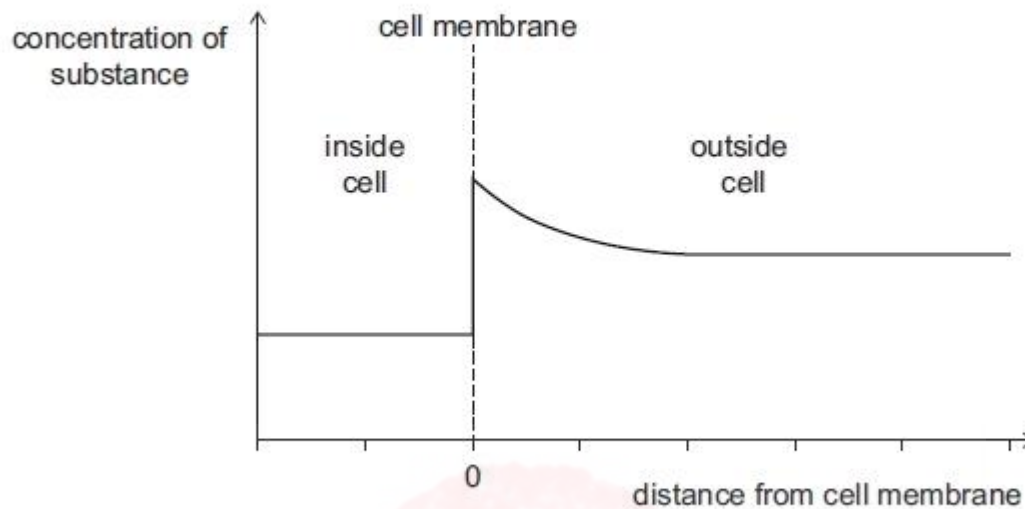
Which of the following statements is/are correct?

- 1 In the cell in distilled water, Q contains only distilled water.
- 2 In the cell in concentrated sugar solution, the number of solute particles in Q increased over the two hours.
- 3 S is a vacuum.

- A none of them
- B 1 only
- C 2 only
- D 3 only
- E 1 and 2 only
- F 1 and 3 only
- G 2 and 3 only
- H 1, 2 and 3

- 63** A cell is studied. The graph shows the concentration of a substance at different distances from the cell membrane.

The concentrations shown are maintained over time.



Which of the following processes is/are responsible for maintaining the difference in the concentration of the substance across the membrane?

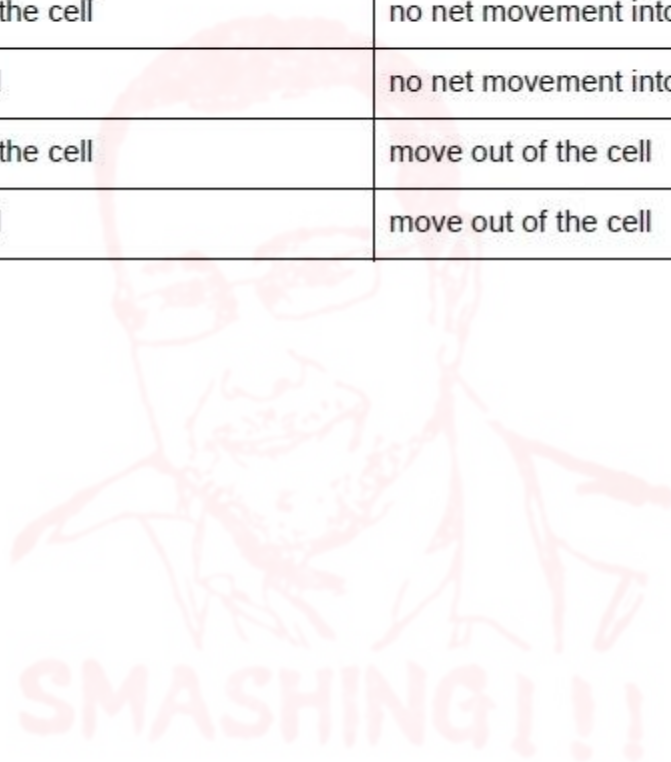
- 1 active transport
 - 2 diffusion
 - 3 osmosis
- A none of them
- B 1 only
- C 2 only
- D 3 only
- E 1 and 2 only
- F 1 and 3 only
- G 2 and 3 only
- H 1, 2 and 3 only

80 An animal cell is surrounded by a very dilute glucose solution which has a lower concentration of glucose than the glucose solution in the cytoplasm of the cell. There is net movement of glucose molecules and water molecules into the cell.

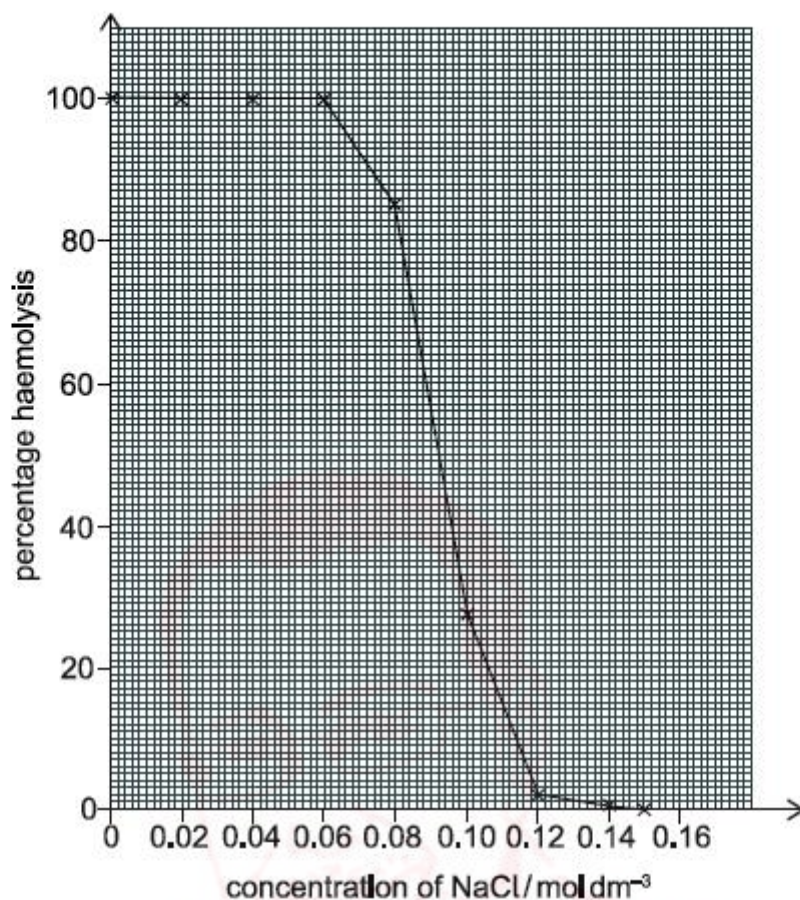
A second, identical cell is treated for a short time with a chemical which inhibits respiration. The cell is then surrounded by the same glucose solution.

Which row in the table shows the effect of this chemical on the movement of glucose molecules into the cell and the movement of water molecules across the cell surface membrane immediately after it is surrounded by the solution?

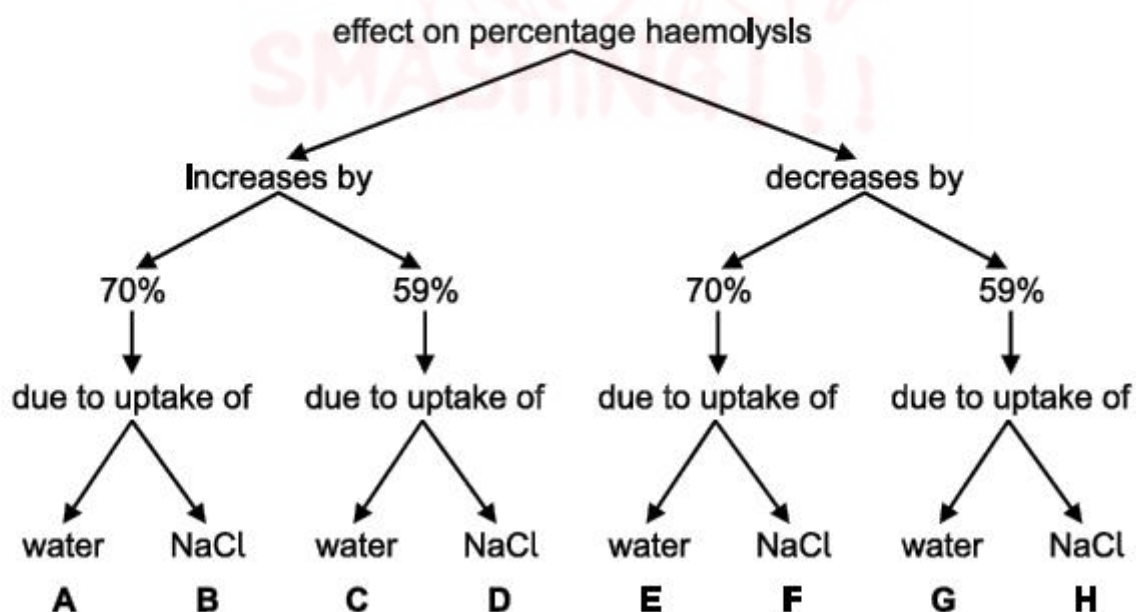
	<i>net movement of glucose molecules</i>	<i>net movement of water molecules</i>
A	do not move into the cell	move into the cell
B	move into the cell	move into the cell
C	do not move into the cell	no net movement into or out of the cell
D	move into the cell	no net movement into or out of the cell
E	do not move into the cell	move out of the cell
F	move into the cell	move out of the cell



- 69 The graph below shows the effect of different concentrations of sodium chloride (NaCl) solution on the percentage haemolysis of human red blood cells. Haemolysis occurs when the cells swell and then burst open.



Which letter correctly describes the effect of changing the concentration of NaCl from 0.12 mol dm⁻³ to 0.084 mol dm⁻³ on percentage haemolysis?



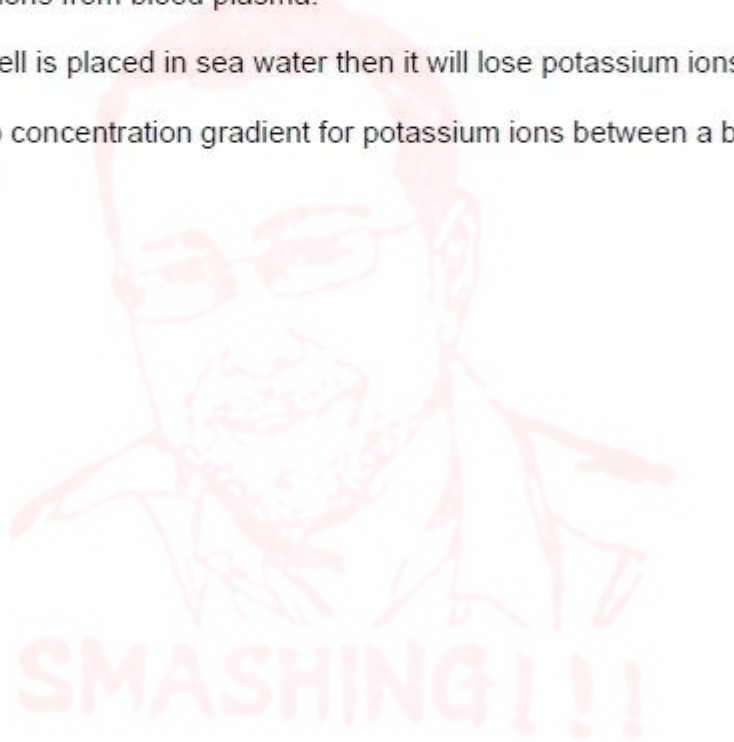
71 The table shows the concentration of potassium ions in several different locations.

<i>location</i>	<i>concentration of potassium ions</i>
bacterial cell cytoplasm	30 mmol dm^{-3}
mammalian blood plasma	$4000 \text{ } \mu\text{mol dm}^{-3}$
mammalian heart cell cytoplasm	$1.0 \times 10^2 \text{ mmol dm}^{-3}$
sea water	$3.0 \times 10^4 \text{ } \mu\text{mol dm}^{-3}$
yeast cell cytoplasm	300 mmol dm^{-3}

Which of the following statements is/are correct?

- 1** A mammalian heart cell needs energy from respiration in order to obtain more potassium ions from blood plasma.
- 2** If a yeast cell is placed in sea water then it will lose potassium ions by osmosis.
- 3** There is no concentration gradient for potassium ions between a bacterial cell and sea water.

- A** none of them
- B** 1 only
- C** 2 only
- D** 3 only
- E** 1 and 2 only
- F** 1 and 3 only
- G** 2 and 3 only
- H** 1, 2 and 3



62 A cell from the epithelium of an animal was removed. The cytoplasm of this cell can be considered as a 2% sugar solution. The living cell was placed in a 4% sugar solution.

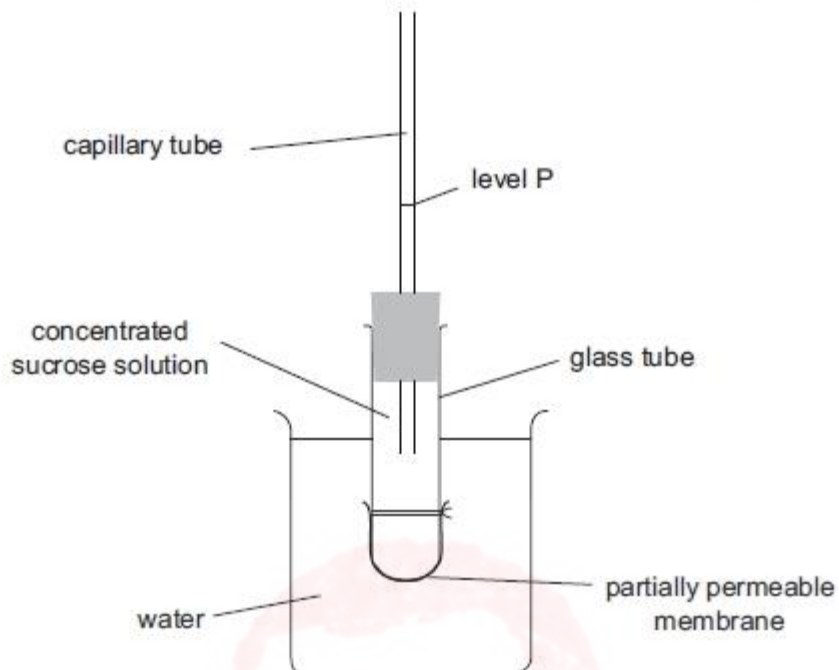
Which of the following statements is/are correct?

- 1 At equilibrium, the sugar concentration in the cell was 6%.
- 2 Water continued to move across the cell membrane after equilibrium was reached.
- 3 Osmosis was most rapid when the cell was first placed in the solution.

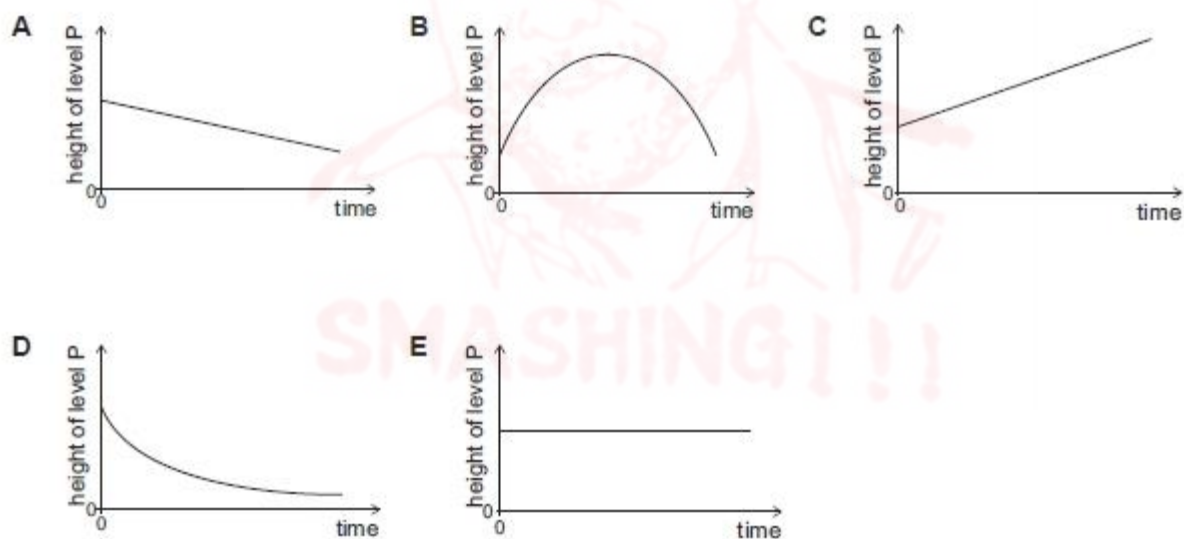
- A none of them
- B 1 only
- C 2 only
- D 3 only
- E 1 and 2 only
- F 1 and 3 only
- G 2 and 3 only
- H 1, 2 and 3



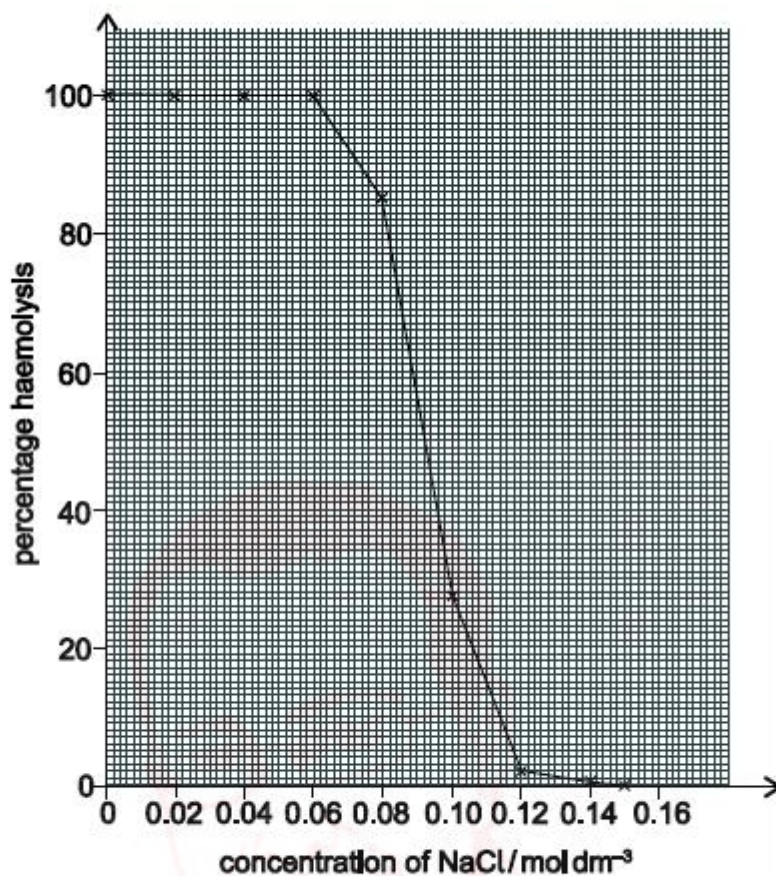
- 65 The diagram shows the apparatus used to investigate the movement of molecules across a partially permeable membrane. Sucrose is unable to cross the partially permeable membrane.



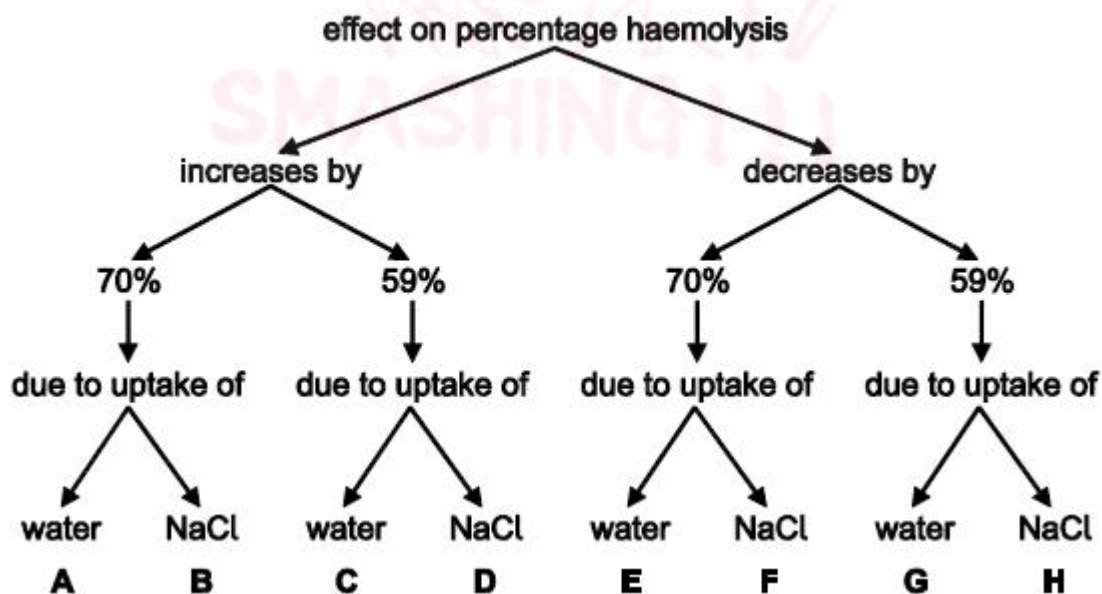
Which graph correctly shows how the height of solution in the capillary tube changes over 15 minutes?



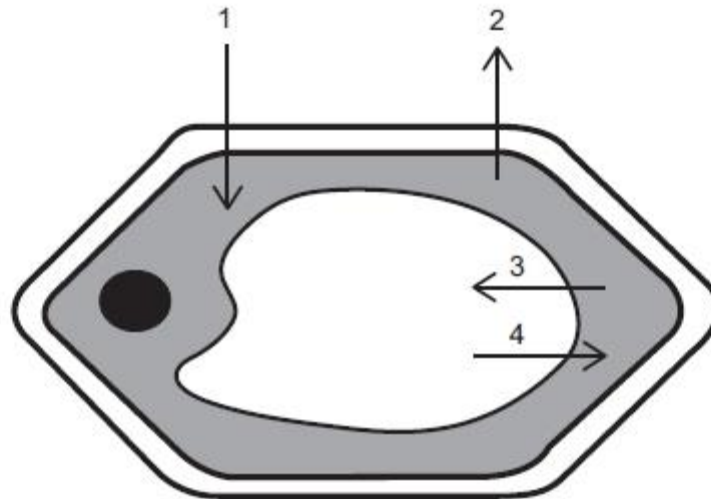
- 63 The graph below shows the effect of different concentrations of sodium chloride (NaCl) solution on the percentage haemolysis of human red blood cells. Haemolysis occurs when the cells swell and then burst open.



Which letter correctly describes the effect of changing the concentration of NaCl from 0.12 mol dm⁻³ to 0.084 mol dm⁻³ on percentage haemolysis?



56 The diagram shows a plant cell.



Which of the arrows on the diagram show the **net** movement of water molecules, by osmosis, when the cell is surrounded by a solution that is more concentrated than the solution in the cytoplasm?

- A 1 only
- B 2 only
- C 1 and 3 only
- D 1 and 4 only
- E 2 and 3 only
- F 2 and 4 only

Topic 5 Q# 48/ Cambridge/2024/ESAT/ Biology/ Q# 7 /www.SmashingScience.org/

Which of the following statements is/are correct about a stem cell extracted from the bone marrow of a healthy human donor to be given to a patient?

1. It can undergo meiosis to form genetically identical offspring.
2. It may contain 46 chromosomes.
3. It could differentiate to become a white blood cell.

- ☐ none of them
- ☐ 1 only
- ☐ 2 only
- ☐ 3 only
- ☐ 1 and 2 only
- ☐ 1 and 3 only
- ☐ 2 and 3 only
- ☐ 1, 2 and 3

Which of the following could be produced when a mutation occurs in a cheek cell of an organism?

1. a change in the sequence of amino acids used to make a protein
2. an advantageous allele that can be passed on to the offspring of that organism
3. a change of an essential cell process that causes the death of the cell

- ☐ none of them
- ☐ 1 only
- ☐ 2 only
- ☐ 3 only
- ☐ 1 and 2 only
- ☐ 1 and 3 only
- ☐ 2 and 3 only
- ☐ 1, 2 and 3

Which of the following describe(s) a role of mitosis?

1. formation of gametes
2. growth of cells
3. repair of cells
4. replacement of skin cells

- ☐ 1 only
- ☐ 2 only
- ☐ 3 only
- ☐ 4 only
- ☐ 1 and 2 only
- ☐ 3 and 4 only
- ☐ 1, 3 and 4 only
- ☐ 1, 2, 3 and 4

80 Four blood cells were taken from a human:

- one that was about to start cytokinesis
- one actively producing antibodies
- two that cannot use oxygen for respiration

What is the total number of chromosomes present in all of the cells mentioned above?

(Ignore mitochondrial DNA.)

- A 92
- B 115
- C 138
- D 161
- E 184
- F 207

Topic 5 Q# 52/ Cambridge/2023/Section 1/ Biology NSAA/ Q# 66 /www.SmashingScience.org/

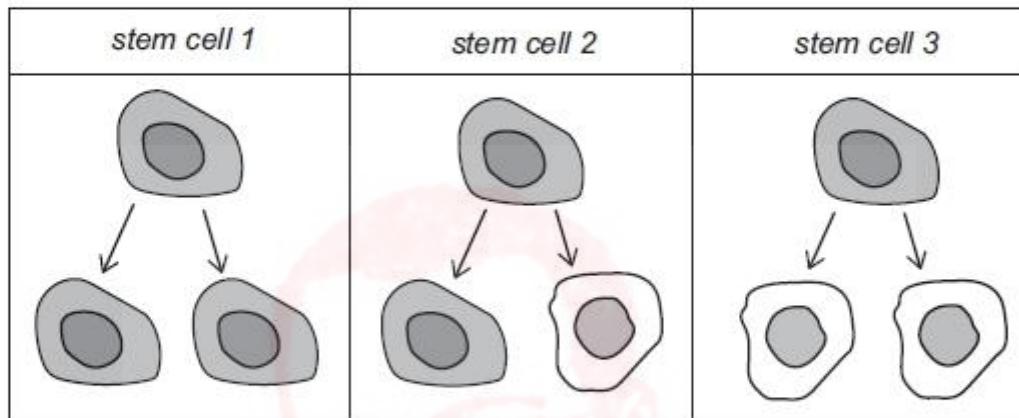
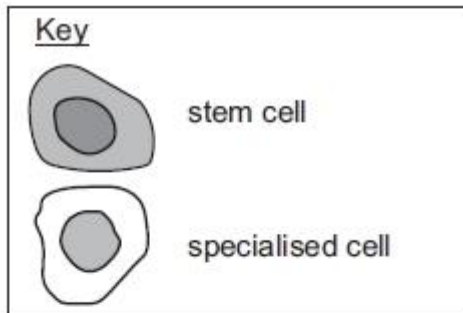
66 A chemical was added to a cell dividing by mitosis. This chemical binds to molecules, preventing the separation of the replicated chromosomes.

Using this information, which of the following effects could this chemical have on this cell division?

- 1 The four daughter cells contain double the normal number of chromosomes.
- 2 The gametes contain the haploid number of chromosomes.
- 3 The cell does not divide and contains the diploid number of replicated chromosomes.

- A none of them
- B 1 only
- C 2 only
- D 3 only
- E 1 and 2 only
- F 1 and 3 only
- G 2 and 3 only
- H 1, 2 and 3

75 The diagrams show the daughter cells produced when three different stem cells divide.



Which of the following statements is correct?

- A Only stem cell 1 shows division by mitosis.
- B Some cancers result from divisions like that shown for stem cell 1.
- C The total number of stem cells increases if they divide like stem cell 2.
- D Stem cells in adults divide like stem cell 3.
- E The total number of stem cells is maintained if they divide like stem cell 3.

77 Which of the following could be produced when a mutation occurs in a cheek cell of an organism?

- 1 a change in the sequence of amino acids used to make a protein
- 2 an advantageous allele that can be passed on to the offspring of that organism
- 3 a change of an essential cell process that causes the death of the cell

- A none of them
- B 1 only
- C 2 only
- D 3 only
- E 1 and 2 only
- F 1 and 3 only
- G 2 and 3 only
- H 1, 2 and 3

66 Which of the following statements is/are correct about a stem cell extracted from the bone marrow of a healthy human donor to be given to a patient?

- 1 It can undergo meiosis to form genetically identical offspring.
- 2 It may contain 46 chromosomes.
- 3 It could differentiate to become a white blood cell.

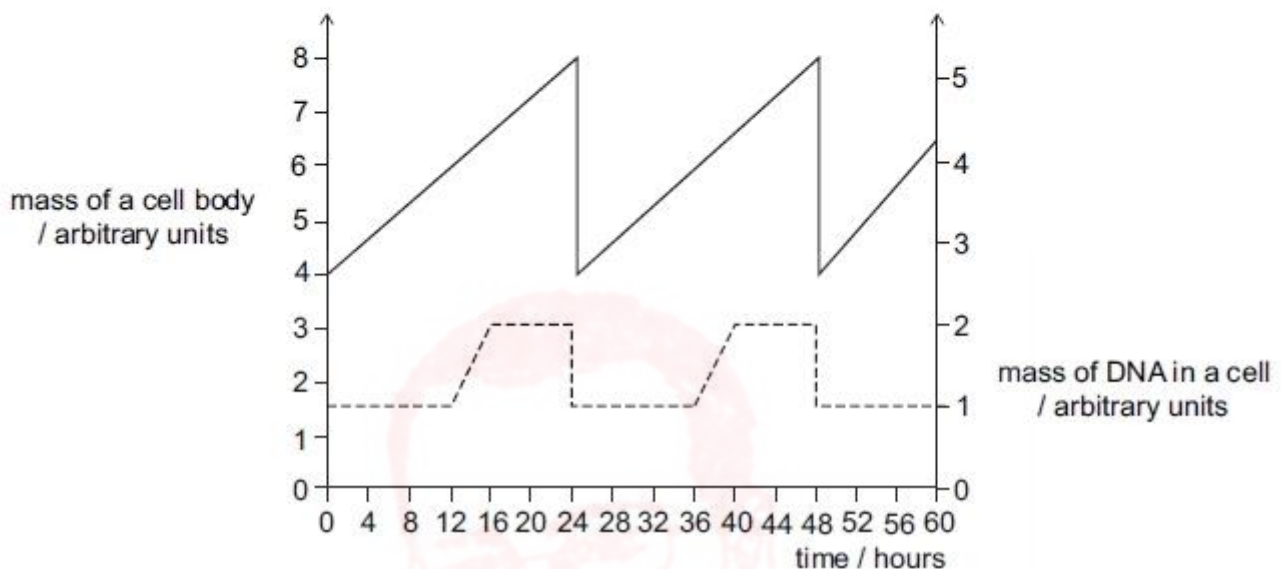
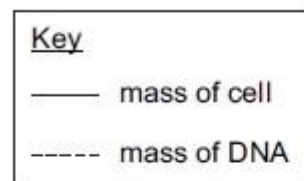
- A none of them
- B 1 only
- C 2 only
- D 3 only
- E 1 and 2 only
- F 1 and 3 only
- G 2 and 3 only
- H 1, 2 and 3

61 Which of the following describe(s) a role of mitosis?

- 1 formation of gametes
 - 2 growth of cells
 - 3 repair of cells
 - 4 replacement of skin cells
-
- A 1 only
 - B 2 only
 - C 3 only
 - D 4 only
 - E 1 and 2 only
 - F 3 and 4 only
 - G 1, 3 and 4 only
 - H 1, 2, 3 and 4



70 The graphs represent the changes in the mass of a healthy human body cell and in the mass of the DNA of that cell over time.



Using the graph, which of the following statements is/are correct?

- 1 Mitosis takes place at 12 and 36 hours.
- 2 The graph shows two cell divisions.
- 3 The next cell division should take place at 72 hours.

- A none of them
- B 1 only
- C 2 only
- D 3 only
- E 1 and 2 only
- F 1 and 3 only
- G 2 and 3 only
- H 1, 2 and 3



The student drew the following conclusions about the two cells labelled X and Y.

- 1 Both cells X and Y are found in the same tissue.
- 2 Both cells X and Y were produced by mitosis.
- 3 Both cells X and Y have a cell wall.

Which of these conclusions is/are correct?

- A none of them
- B 1 only
- C 2 only
- D 3 only
- E 1 and 2 only
- F 1 and 3 only
- G 2 and 3 only
- H 1, 2 and 3

58 Which of the following statements about stem cells in a healthy human female is/are correct?

- 1 An adult stem cell contains the same genes as an epithelial cell from that organism.
- 2 Stem cells from this human will all contain two X chromosomes.
- 3 When a stem cell divides it produces a new stem cell plus two specialised body cells.

(Assume that no mutations have occurred.)

- A none of them
- B 1 only
- C 2 only
- D 3 only
- E 1 and 2 only
- F 1 and 3 only
- G 2 and 3 only
- H 1, 2 and 3

72 Which of the following could be found in an adult liver cell?

- 1 starch
- 2 at least one X chromosome
- 3 gene for amylase

- A 1 only
- B 2 only
- C 3 only
- D 1 and 2 only
- E 1 and 3 only
- F 2 and 3 only
- G 1, 2 and 3
- H none of them

70 Which of the following could be produced when a mutation occurs in a cheek cell of an organism?

- 1 a change in the sequence of amino acids used to make a protein
- 2 an advantageous allele that can be passed on to the offspring of that organism
- 3 a change of an essential cell process that causes the death of the cell

- A 1 only
- B 2 only
- C 3 only
- D 1 and 2 only
- E 1 and 3 only
- F 2 and 3 only
- G 1, 2 and 3

66 The sex of a species of fruit fly is determined by the number of X chromosomes relative to the number of non-sex chromosomes (A) in a cell. This is called the X:A ratio.

A fruit fly will be male if $X:A = 0.5:1$ and female if $X:A = 1:1$

The Y chromosome contains genes necessary for making sperm.

Which row of the table correctly shows the sex of the five fruit flies with different numbers of these chromosomes?

	XAA	XYAA	XXAA	XXYAA	XXYYAA
A	female	female	female	male	male
B	female	female	male	male	male
C	female	male	female	male	female
D	female	male	female	male	male
E	male	female	male	female	female
F	male	female	male	female	male
G	male	male	female	female	female
H	male	male	female	female	male

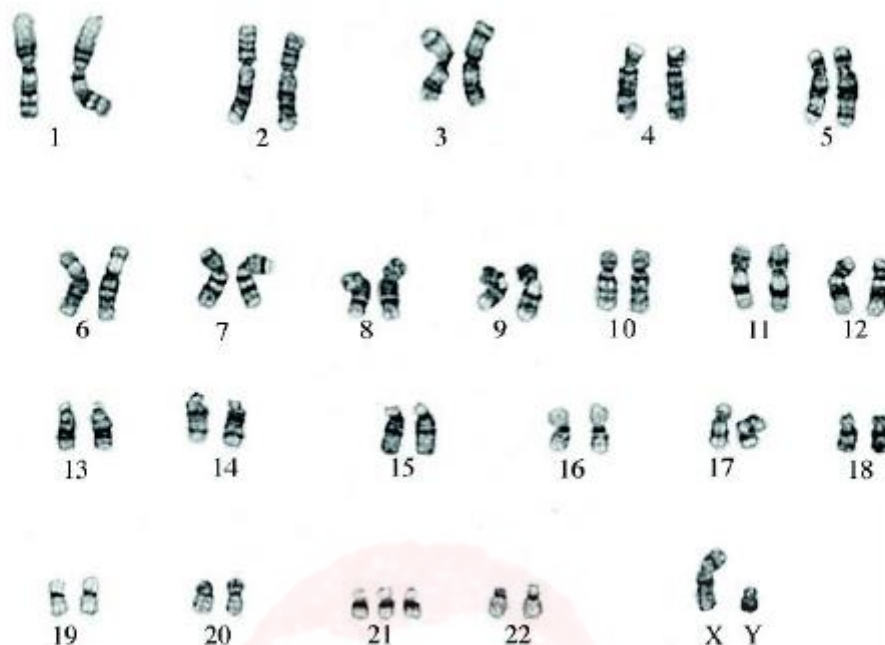
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- 1 It can undergo meiosis to form genetically identical offspring.
- 2 It may contain 46 chromosomes.
- 3 It could differentiate to become a white blood cell.

- A 1 only
- B 2 only
- C 3 only
- D 1 and 2 only
- E 1 and 3 only
- F 2 and 3 only
- G 1, 2 and 3
- H none of them



59 The karyogram below is a photograph of the chromosomes taken from a single human cell.



Using the karyogram, which of the following statements is/are correct?

- 1 The person is healthy with no visible mutations.
- 2 These chromosomes come from a male cell.
- 3 The cell used could have been a white blood cell.

- A 1 only
- B 2 only
- C 3 only
- D 1 and 2 only
- E 1 and 3 only
- F 2 and 3 only
- G 1, 2 and 3

Image used with permission of UW Cytogenetics/Wisconsin State Laboratory of Hygiene © Board of Regents of the University of Wisconsin System

55 Which of the following describe(s) a role of mitosis?

- 1 formation of gametes
- 2 growth of cells
- 3 repair of cells
- 4 replacement of skin cells

- A 1 only
- B 2 only
- C 3 only
- D 4 only
- E 1 and 2 only
- F 3 and 4 only
- G 1, 3 and 4 only
- H 1, 2, 3 and 4

Topic 6 Q# 66/ Cambridge/2024/ESAT/ Biology/ Q# 21 /www.SmashingScience.org/

A section of DNA is 420 base pairs long and contains 42% of one of the bases, adenine (A).

Which one of the following rows in the table correctly states how many amino acids can be coded for by this section of DNA and what percentage of the base guanine (G) is present in this section of DNA?

	<i>number of amino acids</i>	<i>percentage of guanine (G)</i>
A	140	8
B	140	13
C	140	42
D	260	16
E	260	42
F	420	8
G	420	13
H	420	16

- ☐ A
- ☐ B
- ☐ C
- ☐ D
- ☐ E
- ☐ F
- ☐ G
- ☐ H

77 The sugar present in DNA contains 5 carbons.

A section of single-stranded DNA contains five different triplets.

Which of the following statements about this strand could be correct?

- 1 There are 75 carbons in the sugar–phosphate backbone in this section.
- 2 The minimum number of different bases present in the base sequence is 2.
- 3 The number of sugar-to-phosphate bonds is equal to the number of nucleotides.

A none of them

B 1 only

C 2 only

D 3 only

E 1 and 2 only

F 1 and 3 only

G 2 and 3 only

H 1, 2 and 3



75 The same section of a gene was taken from two different people and the DNA sequenced to show the triplets on one strand.

The results for each person are shown.

<i>person 1</i>	TCC	GCG	AGC	CCC	TTG	AGG
<i>person 2</i>	TCC	GCG	AGC	CCG	TTA	AGG

Which of the following statements about the sequences could be correct?

- 1 Person 2 has one mutation in the section of the gene.
- 2 Both people have the same phenotype for this gene.
- 3 This section of the gene codes for up to 6 bases.

- A none of them
- B 1 only
- C 2 only
- D 3 only
- E 1 and 2 only
- F 1 and 3 only
- G 2 and 3 only
- H 1, 2 and 3



70 One strand of a section of DNA has the following sequence of bases:

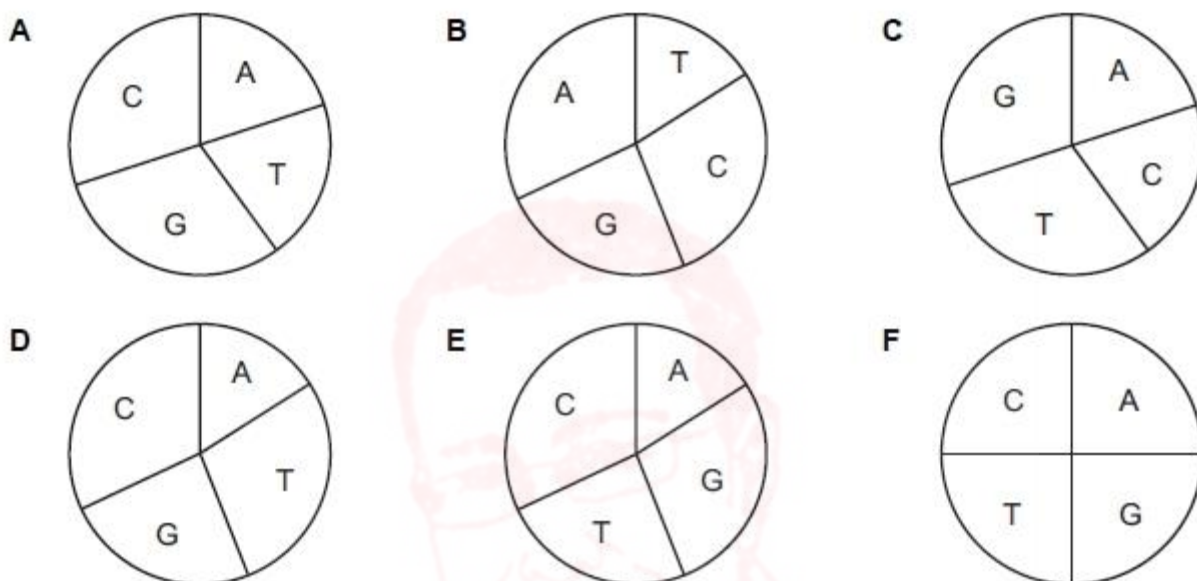
AATCGGTCTTGCGGCCAAGGCCCTT

The complementary strand is not shown.

The charts show the proportions of the four bases A, C, G and T.

Which chart shows the correct proportions of bases for this section of double-stranded DNA?

(Assume no mutations.)



75 A section of DNA is 420 base pairs long and contains 42% of one of the bases, adenine (A).

Which one of the following rows in the table correctly states how many amino acids can be coded for by this section of DNA and what percentage of the base guanine (G) is present in this section of DNA?

	<i>number of amino acids</i>	<i>percentage of guanine (G)</i>
A	140	8
B	140	13
C	140	42
D	260	16
E	260	42
F	420	8
G	420	13
H	420	16

63 A section of double-stranded DNA contains 4500 base pairs. 10% of the bases present are adenine.

Which of the following statements is/are correct?

- 1** There are 450 thymine bases present.
- 2** 40% of the bases present are cytosine.
- 3** There are 3600 guanine bases present.

- A** none of them
- B** 1 only
- C** 2 only
- D** 3 only
- E** 1 and 2 only
- F** 1 and 3 only
- G** 2 and 3 only
- H** 1, 2 and 3



72 The sequence of a coding section of DNA is shown below.

CTAGTCTGGTGGCTACGTCCTCCTCTACTATGGCTAGTCGTCTGGTGGCTA

The number of each type of amino acid coded for by this sequence of DNA bases is shown in the table.

<i>amino acid coded for</i>	<i>number of this type of amino acid present</i>
Arg	1
Leu	6
Pro	2
Trp	5
Val	3

What is the correct sequence of amino acids coded for by this sequence of DNA?

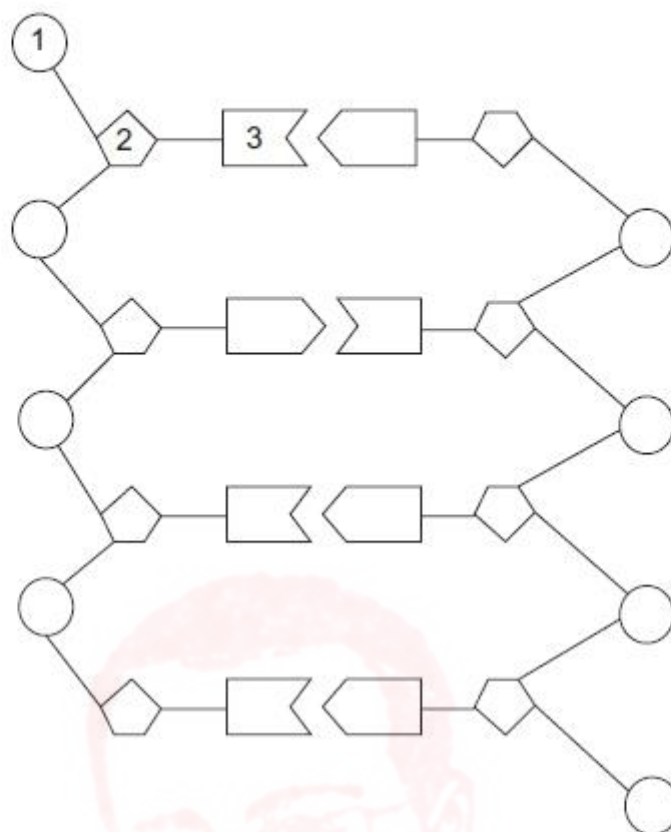
- A Leu-Trp-Trp-Leu-Arg-Pro-Pro-Leu-Leu-Val-Leu-Val-Val-Trp-Trp-Trp
- B Leu-Trp-Trp-Leu-Arg-Pro-Pro-Leu-Leu-Trp-Leu-Trp-Val-Val-Val-Val
- C Leu-Val-Trp-Trp-Leu-Arg-Pro-Pro-Leu-Leu-Trp-Leu-Val-Val-Trp-Trp
- D Leu-Trp-Trp-Leu-Arg-Pro-Pro-Leu-Leu-Val-Leu-Val-Val-Trp-Trp-Trp-Leu
- E Leu-Trp-Trp-Leu-Arg-Pro-Pro-Leu-Leu-Trp-Leu-Trp-Val-Val-Val-Val-Leu
- F Leu-Leu-Trp-Trp-Leu-Arg-Pro-Pro-Leu-Leu-Trp-Leu-Val-Val-Trp-Trp-Val
- G Leu-Val-Trp-Trp-Leu-Leu-Pro-Pro-Leu-Leu-Trp-Leu-Val-Val-Trp-Trp-Leu
- H Leu-Val-Trp-Trp-Leu-Arg-Pro-Pro-Leu-Leu-Trp-Leu-Val-Val-Trp-Trp-Leu

65 Which of the following may stay the same when a mutation occurs in a human gene that codes for a protein?

- 1 the genotype of the organism's offspring
- 2 the phenotype of the organism
- 3 the sequence of amino acids in the protein

- A none of them
- B 1 only
- C 2 only
- D 3 only
- E 1 and 2 only
- F 1 and 3 only
- G 2 and 3 only
- H 1, 2 and 3





What do the parts labelled 1, 2 and 3 represent?

	1	2	3	1 and 2 and 3
A	base	phosphate	glycerol	gene
B	base	sugar	amino acid	gene
C	phosphate	sugar	base	nucleotide
D	phosphate	sugar	base	DNA strand
E	sugar	phosphate	base	nucleotide
F	sugar	phosphate	fatty acid	DNA strand

- 69** A student analysed a gene sequence that had been identified in four different types of organism. The gene codes for a functional protein. A section of the gene's DNA is shown below. The rest of the DNA from this gene (not shown) is identical in all four different types of organism.

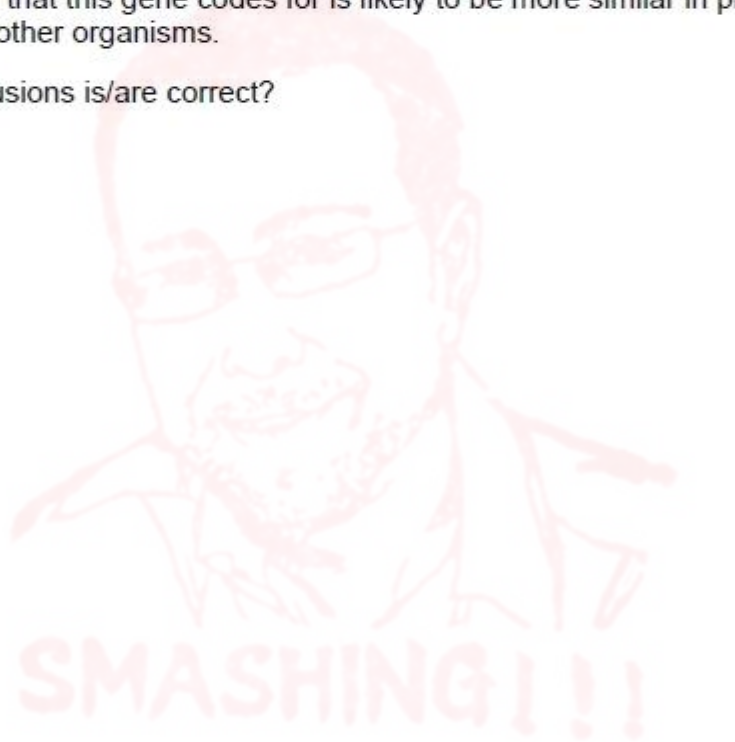
<i>organism</i>	<i>DNA sequence</i>					
human	ACG	CCT	CGT	CAC	GCT	AAA
oak tree	ACG	GAA	TAT	GTA	GCT	AAA
mushroom	ACG	GAA	CTC	TTA	GCT	AAA
<i>E.coli</i> bacterium	ACG	TAC	GAT	GGG	GCT	AAA

The student then made the following conclusions:

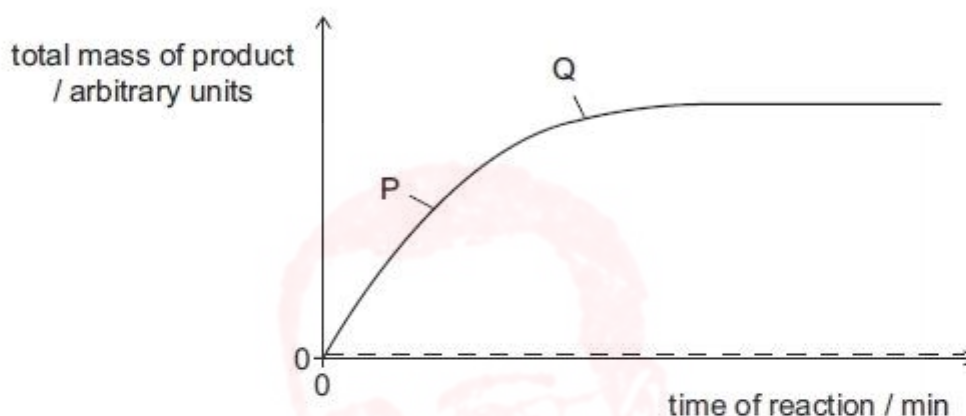
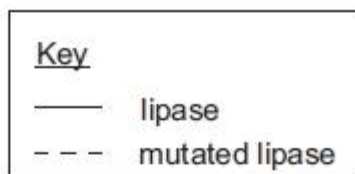
- 1 This gene does not code for chlorophyll.
- 2 This gene may be found in the nucleus or cytoplasm.
- 3 The protein that this gene codes for is likely to be more similar in plants and fungi than in the other organisms.

Which of these conclusions is/are correct?

- A none of them
- B 1 only
- C 2 only
- D 3 only
- E 1 and 2 only
- F 1 and 3 only
- G 2 and 3 only
- H 1, 2 and 3



- 64 In a laboratory, the activity of two lipase enzymes on the same type of lipid was studied. One lipase enzyme was produced from a mutation in the gene that coded for the original enzyme. The mutation occurred in the sequence for three adjacent amino acids called serine, aspartic acid and histidine. The graph shows the results of this study.



Which of the following statements is/are correct?

- 1 The serine, aspartic acid and histidine amino acids could be in the active site of the enzyme.
- 2 All mutations affecting the region coding for serine, aspartic acid and histidine amino acids will be expected to have the same effect.
- 3 At point Q on the graph, the pH of the reaction mixture will be higher than at P.

- A none of them
- B 1 only
- C 2 only
- D 3 only
- E 1 and 2 only
- F 1 and 3 only
- G 2 and 3 only
- H 1, 2 and 3

63 A piece of DNA is made up of two complementary strands, each 25 bases long.

14% of the bases are adenine.

Which two statements are correct?

- 1 Adenine and cytosine together make up 25 bases.
- 2 Adenine and guanine together make up 50% of the bases.
- 3 There are 14 thymine bases present.
- 4 36 of the bases are guanine.

- A 1 and 2 only
- B 1 and 3 only
- C 1 and 4 only
- D 2 and 3 only
- E 2 and 4 only
- F 3 and 4 only



70 The table shows some of the genetic codes for amino acids:

<i>genetic code</i>	<i>amino acid coded for (three-letter abbreviations)</i>
AGA	Arg
AGG	Arg
ATG	Met
CCC	Pro
CCG	Pro
CGA	Arg
CTG	Leu
GAC	Asp
GGA	Gly
GTC	Val
GTG	Val
TAG	Stop (ends protein synthesis)
TGG	Trp
TTA	Leu
TTG	Leu

The base sequence below shows the middle part of a gene coding for a protein:

ATG CGA GAC ATG TTA AGG TGG GAC CCC CGA GTC

Mutations took place in both the 4th and 20th base in this sequence.

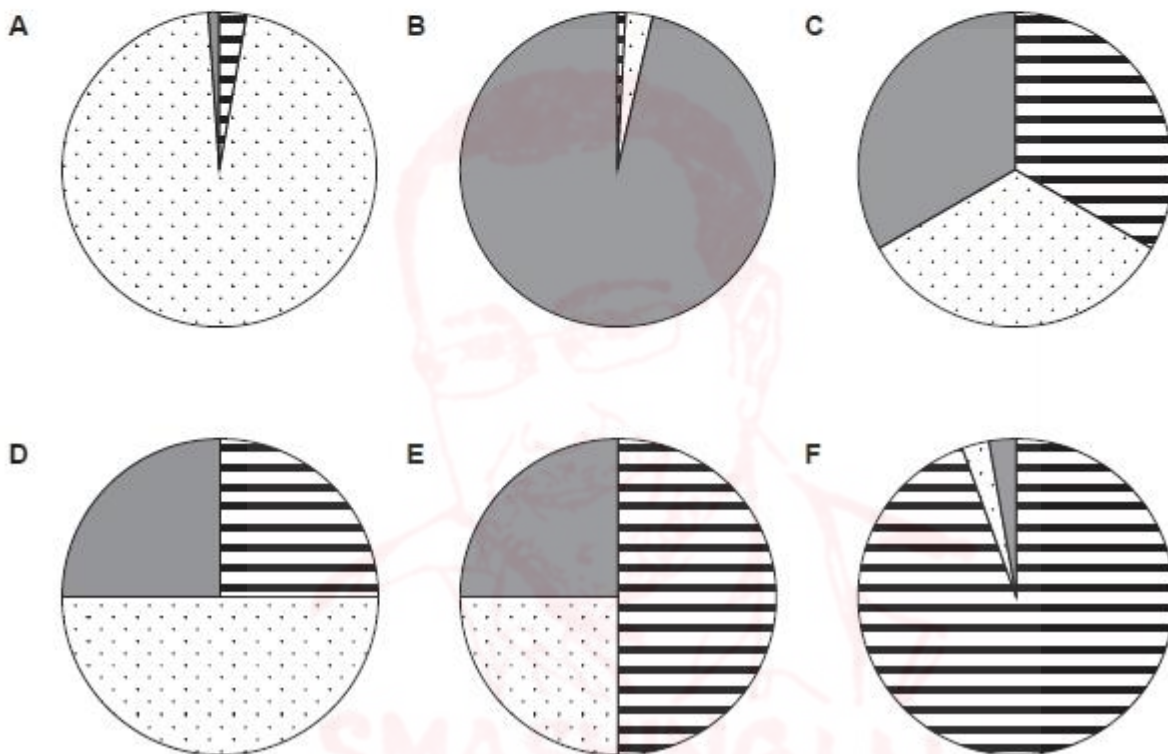
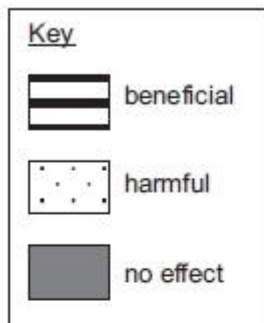
Using **only** the information provided and reading the sequence from left to right, which of the following statements **could** be correct for the resulting amino acid sequence after the two mutations took place?

- 1 This sequence could be only six amino acids long.
- 2 The second amino acid in this sequence could be unaffected by the mutation.
- 3 This amino acid sequence could contain seven different amino acids.

- A none of them
- B 1 only
- C 2 only
- D 3 only
- E 1 and 2 only
- F 1 and 3 only
- G 2 and 3 only
- H 1, 2 and 3

56 Spontaneous mutations occur in the genetic material of all living organisms.

Which pie chart best represents the proportion of mutations that are beneficial, mutations that are harmful, and mutations that have no effect?



- 72 The table shows the DNA base triplet codes that are valid for this question and the amino acids that they code for.

<i>DNA base triplet</i>	<i>amino acid</i>
CGT	arginine
CGC	arginine
CGA	arginine
CGG	arginine
CTG	leucine
CCG	proline
CAG	glutamine
CAT	histidine
AGT	serine

Consider the part of the DNA sequence shown:

... CGC AGT ... →

Two mutations will occur in the DNA sequence. The initial mutation is an insertion of an additional base between the first and second bases in the sequence. The second mutation, which takes place some time after the first mutation, is a deletion that removes one base from the sequence.

Assuming that this DNA sequence is part of a longer sequence coding for a protein, and that no other mutations are occurring, what are the probabilities of the following?

	<i>probability that after the first mutation, the first triplet in this sequence does not code for arginine</i>	<i>probability that after the second mutation, both of the triplets in this sequence code for arginine</i>
A	$\frac{1}{4}$	$\frac{1}{28}$
B	$\frac{1}{4}$	$\frac{1}{24}$
C	$\frac{1}{4}$	$\frac{11}{28}$
D	$\frac{1}{4}$	$\frac{10}{24}$
E	$\frac{3}{4}$	$\frac{1}{28}$
F	$\frac{3}{4}$	$\frac{1}{24}$
G	$\frac{3}{4}$	$\frac{11}{28}$
H	$\frac{3}{4}$	$\frac{10}{24}$

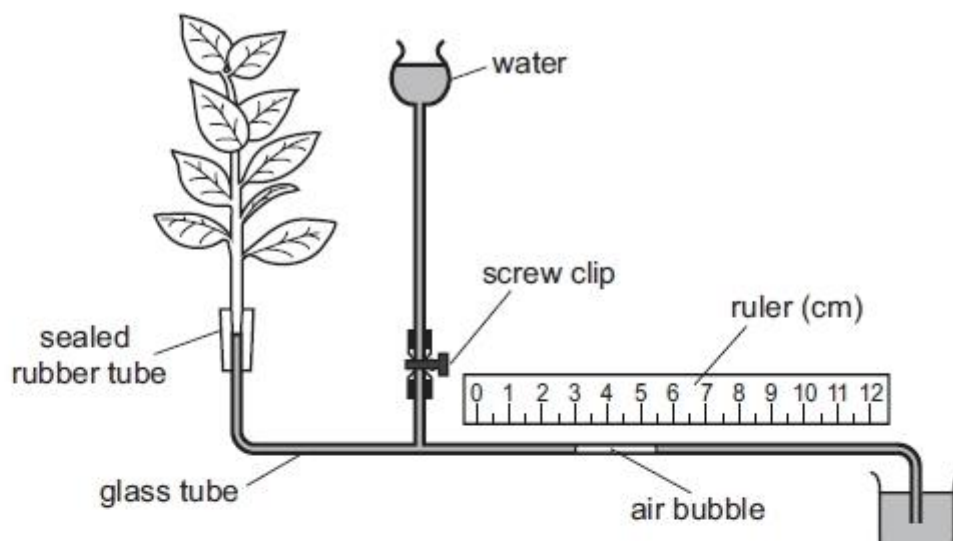
Tomato plants were placed in sunlight in an atmosphere containing radioactively labelled carbon dioxide. After a period of time, radioactively sugars were detected in the roots of the plants.

Which of the following statements is correct?

- ☐ Carbon dioxide diffused into the roots where it was converted into sugars.
- ☐ Carbon dioxide entering the leaves was used to make sugars, some of which were transported by translocation to the roots.
- ☐ Carbon dioxide entering the leaves was used to make sugars, some of which were transported by transpiration to the roots.
- ☐ Carbon dioxide entering the leaves was transported by translocation to the roots where it was converted into sugars.
- ☐ Carbon dioxide entering the leaves was transported by transpiration to the roots where it was converted into sugars.



65 The diagram shows a bubble potometer at the start of an experiment.



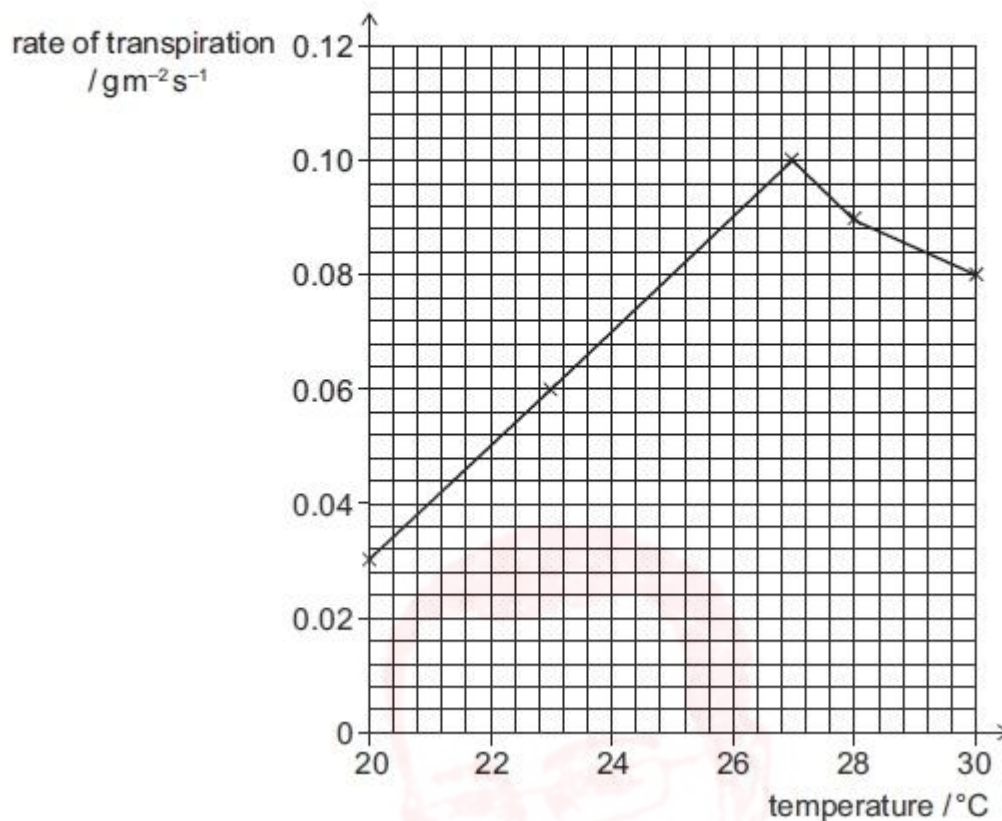
The glass tube has an internal diameter of 1 mm.

After five minutes, one end of the air bubble had moved to the 4 cm mark on the scale.

Which row is correct?

	<i>name of process being investigated</i>	<i>volume of water taken up / mm³</i>
A	translocation	$\pi \times (0.5)^2 \times 10$
B	translocation	$\pi \times (0.5)^2 \times 15$
C	translocation	$2\pi \times (0.5) \times 10$
D	translocation	$2\pi \times (0.5) \times 15$
E	transpiration	$\pi \times (0.5)^2 \times 10$
F	transpiration	$\pi \times (0.5)^2 \times 15$
G	transpiration	$2\pi \times (0.5) \times 10$
H	transpiration	$2\pi \times (0.5) \times 15$

- 73 The graph shows the rate of transpiration at different temperatures for a plant in its natural environment.



Which of the following statements is/are correct?

- 1 Stomata open when the guard cells lose water and become flaccid.
 - 2 Between 20 °C and 27 °C, the humidity around the leaves must have decreased.
 - 3 The air speed around the leaves could be higher at 23 °C than at 30 °C.
- A none of them
- B 1 only
- C 2 only
- D 3 only
- E 1 and 2 only
- F 1 and 3 only
- G 2 and 3 only
- H 1, 2 and 3

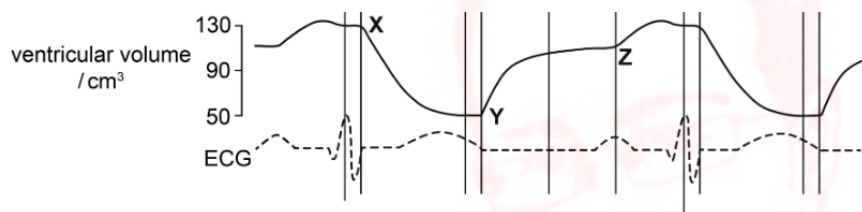
67 Tomato plants were placed in sunlight in an atmosphere containing radioactively labelled carbon dioxide. After a period of time, radioactively labelled sugars were detected in the roots of the plants.

Which of the following statements is correct?

- A** Carbon dioxide diffused into the roots where it was converted into sugars.
- B** Carbon dioxide entering the leaves was used to make sugars, some of which was transported by translocation to the roots.
- C** Carbon dioxide entering the leaves was used to make sugars, some of which was transported by transpiration to the roots.
- D** Carbon dioxide entering the leaves was transported by translocation to the roots where it was converted into sugars.
- E** Carbon dioxide entering the leaves was transported by transpiration to the roots where it was converted into sugars.

Topic 8 Q# 85/ Cambridge/2024/ESAT/ Biology/ Q# 23 /www.SmashingScience.org/

The diagram shows the changes in the volume of the ventricles, and the ECG trace that accompanies those changes, during two consecutive heart beats.



Which row is correct about the events happening at X, Y and Z?

	at X blood is being pumped into	at Y valves between atria and ventricles are	chambers of the heart contracting at Z
A	aorta	open	atria
B	aorta	closed	atria
C	atria	open	ventricles
D	atria	closed	ventricles
E	pulmonary artery	open	ventricles
F	pulmonary artery	closed	ventricles
G	pulmonary vein	open	atria
H	pulmonary vein	closed	atria

- ☐ A
- ☐ B
- ☐ C
- ☐ D
- ☐ E
- ☐ F
- ☐ G
- ☐ H

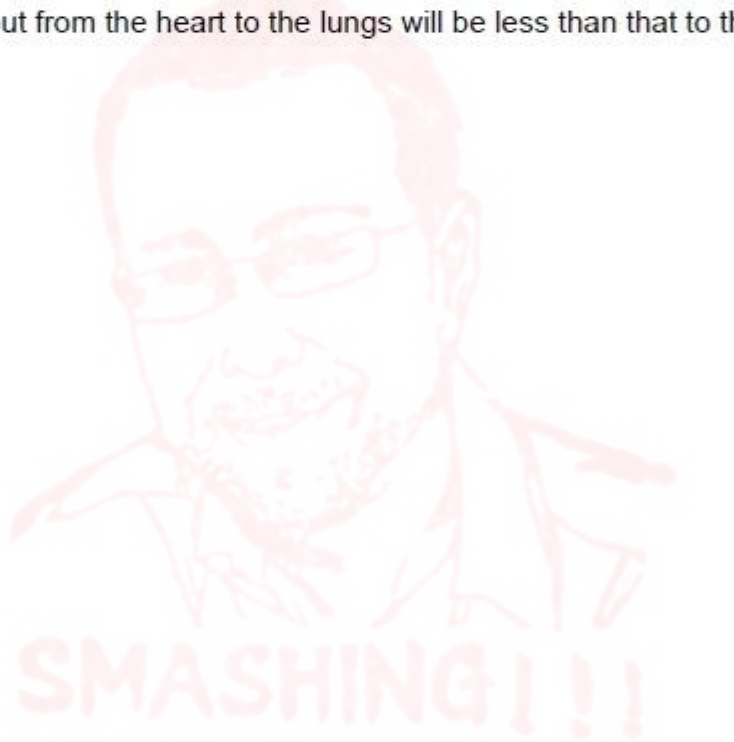
- 69 The table shows the relationship between heart rate and blood output from the left ventricle of a healthy human heart.

<i>heart rate in beats per minute</i>	55	70	80	90	120	140	150	175
<i>blood output in dm³ from the left ventricle of the heart each minute</i>	4.0	5.0	5.2	5.6	6.0	6.0	5.8	4.6

Which of the following statements is/are correct?

- 1 The volume of blood pumped out of the heart each minute is directly proportional to the heart rate.
- 2 When the heart rate increased from 55 to 70 beats per minute, the blood output from the heart increased by 20%.
- 3 Blood output from the heart to the lungs will be less than that to the rest of the body.

- A none of them
- B 1 only
- C 2 only
- D 3 only
- E 1 and 2 only
- F 1 and 3 only
- G 2 and 3 only
- H 1, 2 and 3



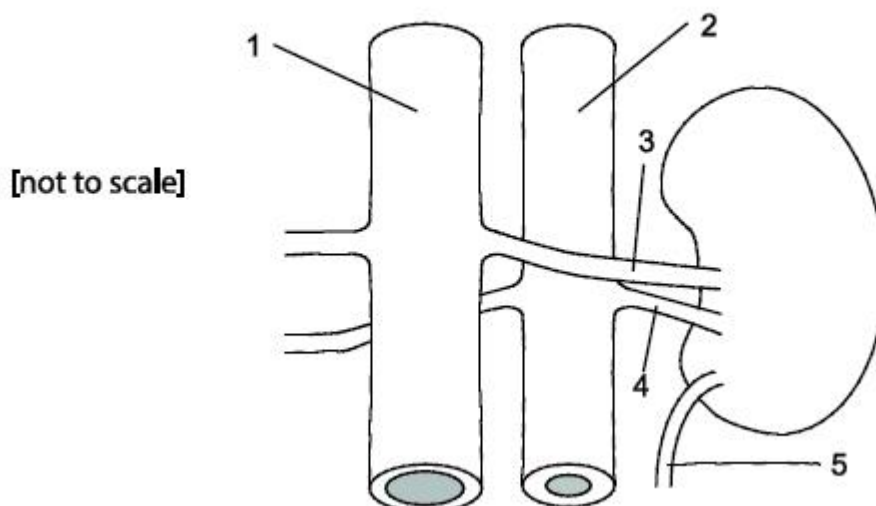
62 Which of the following statements about the cardiovascular system in a healthy individual is/are correct?

- 1 When blood flow in the capillaries is restricted, the rate of oxygen exchanged with the tissues is reduced.
- 2 Oxygen exchange from the blood in the arteries into the tissues is fast due to the high pressure of blood.
- 3 Capillary walls contain a small amount of smooth muscle to constrict the vessels.

- A none of them
- B 1 only
- C 2 only
- D 3 only
- E 1 and 2 only
- F 1 and 3 only
- G 2 and 3 only
- H 1, 2 and 3



70 The diagram shows a kidney and its associated vessels from a healthy individual.

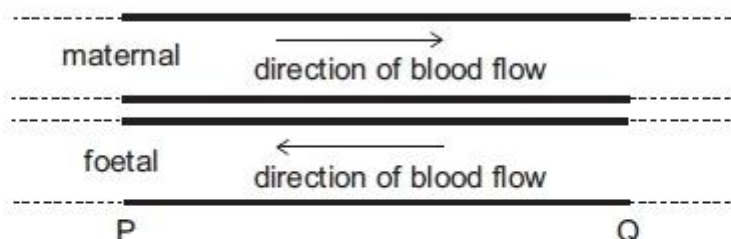


Which row correctly identifies the vessels along with the concentration of urea they contain?

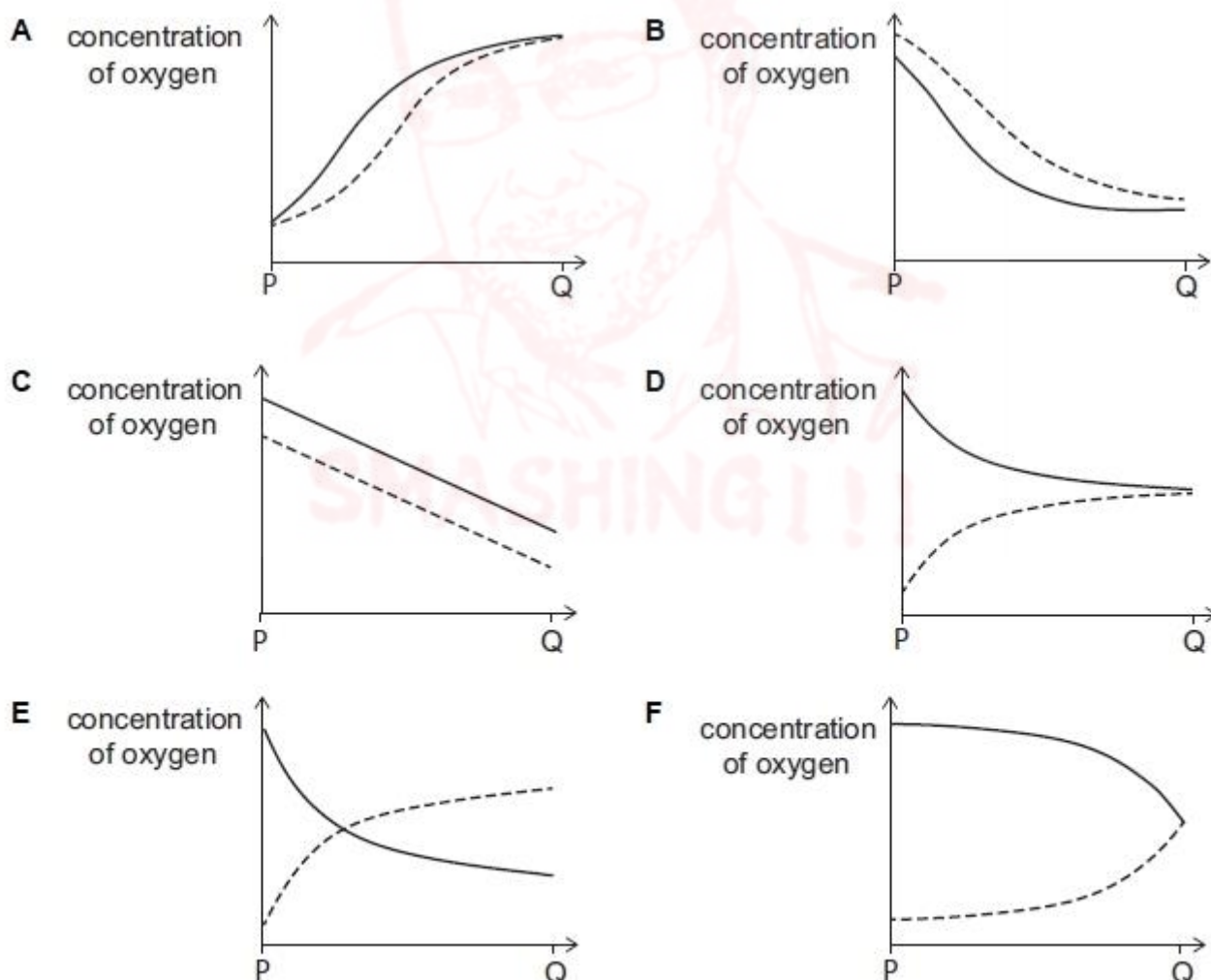
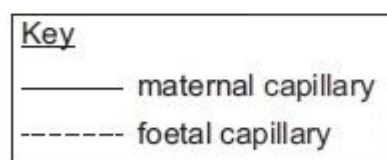
	<i>lowest concentration of urea</i>	<i>highest concentration of urea</i>
A	1 is the aorta	2 is the vena cava
B	1 is the vena cava	2 is the aorta
C	3 is the renal artery	5 is the urethra
D	3 is the renal vein	5 is the ureter
E	4 is the renal vein	5 is the ureter
F	4 is the renal artery	5 is the urethra

- 76** The placenta is an organ that develops during pregnancy. One function of the placenta is to allow the exchange of gases between the mother and the developing fetus.

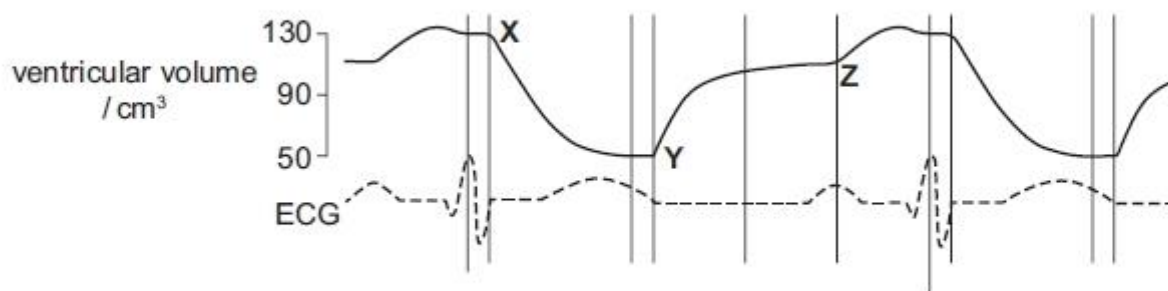
The diagram represents the maternal and foetal blood flow between P and Q in a section of the placenta of a healthy small mammal. The concentration of oxygen in both maternal and foetal blood was measured at regular distances along this section.



Which graph illustrates the concentration of oxygen in both maternal and foetal blood between P and Q?



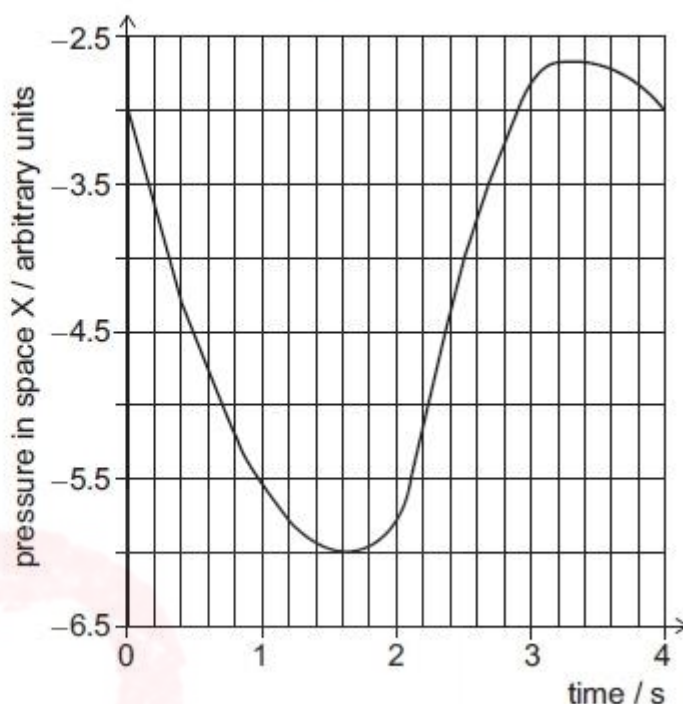
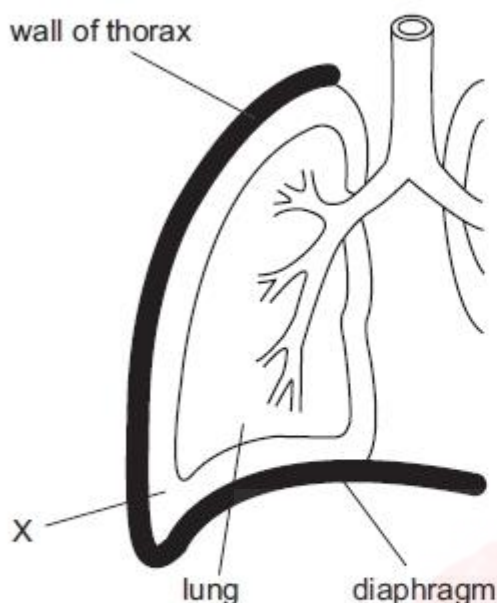
- 75** The diagram shows the changes in the volume of the ventricles, and the ECG trace that accompanies those changes, during two consecutive heart beats.



Which row is correct about the events happening at X, Y and Z?

	<i>at X blood is being pumped into</i>	<i>at Y valves between atria and ventricles are</i>	<i>chambers of the heart contracting at Z</i>
A	aorta	open	atria
B	aorta	closed	atria
C	atria	open	ventricles
D	atria	closed	ventricles
E	pulmonary artery	open	ventricles
F	pulmonary artery	closed	ventricles
G	pulmonary vein	open	atria
H	pulmonary vein	closed	atria

- 78** The graph shows the change in the pressure in the space X between the wall of the thorax and the lungs (as shown in the diagram) during one complete breathing cycle.



Which of the following statements is/are correct?

- 1 The person is breathing out between 0 and 1.5 seconds.
- 2 The diaphragm is relaxing between 2 and 3 seconds.
- 3 The rate of breathing is 15 breaths per minute.

(Assume the person continues breathing at the same rate.)

- A none of them
- B 1 only
- C 2 only
- D 3 only
- E 1 and 2 only
- F 1 and 3 only
- G 2 and 3 only
- H 1, 2 and 3

61 Which of the following is/are correct when a healthy human **breathes in**?

- 1 The ribcage moves up and out because air enters the lungs.
- 2 The volume of the thorax decreases and the thoracic pressure increases.
- 3 Energy is required to contract the intercostal muscles but not the diaphragm.

- A none of them
- B 1 only
- C 2 only
- D 3 only
- E 1 and 2 only
- F 1 and 3 only
- G 2 and 3 only
- H 1, 2 and 3

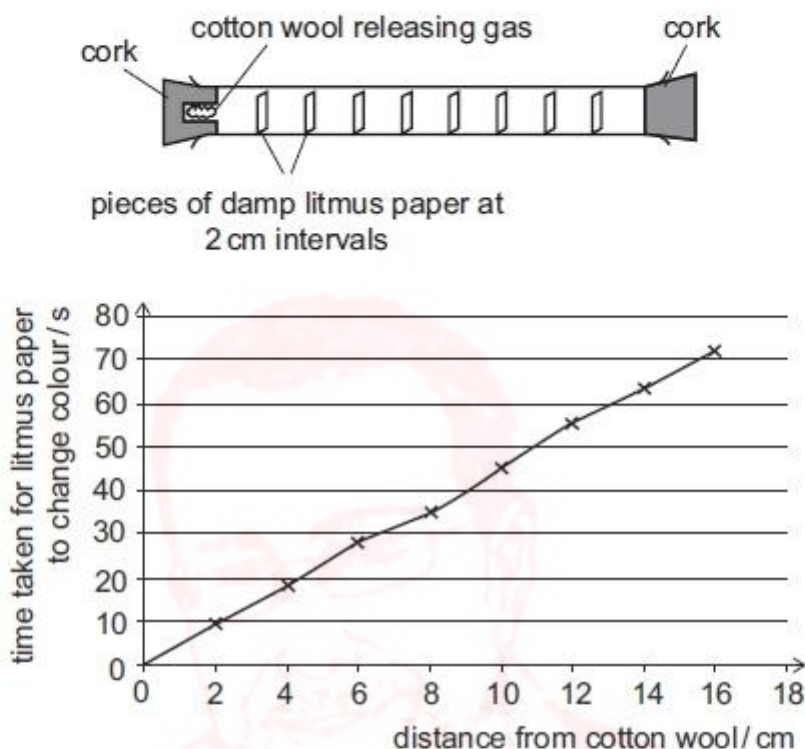


- 61** A student carried out an investigation using the diffusion of a gas along a tube to model movement of gases in the air space of a leaf. An alkaline gas was released from a solution that evaporated from the cotton wool.

As the gas diffused, it caused damp litmus paper to change colour.

The time was recorded when each piece of litmus paper changed colour.

The apparatus and a graph of the results are shown below.



Which of the following statements about the investigation is/are correct?

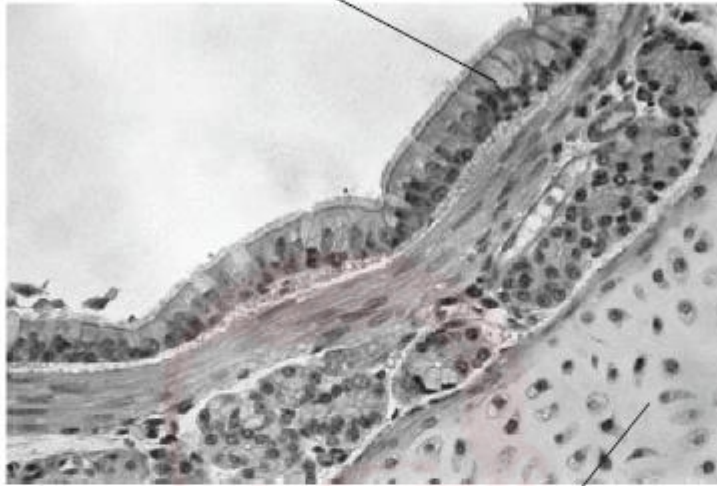
- 1 The dependent variable has been plotted on the x -axis.
- 2 If diffusion of the gas was slower, the graph line would become steeper.
- 3 If a more concentrated solution was used in an identical set of apparatus, the data collected would result in a line on the graph below the points plotted for the original gas.

- A none of them
- B 1 only
- C 2 only
- D 3 only
- E 1 and 2 only
- F 1 and 3 only
- G 2 and 3 only

60 The photomicrograph shows a section through the wall of a human bronchus, one of the tubes which carries air towards the lungs.

A student studying this structure annotated the photomicrograph by describing the cells found in two different layers in the wall of the bronchus.

Two different types of cells are found in this single layer. Goblet cells, which synthesise and secrete the protein in mucus, and cells with cilia, which sweep mucus that has trapped dust and dirt away from the lungs.



A layer consisting of a group of similar cells. Each cell synthesises and secretes a protein that then surrounds the cells.

The student used these observations to write some conclusions.

Which of the following conclusions is/are correct?

- 1 The two different layers are both tissues.
- 2 The bronchus can be described as an organ.
- 3 Amino acids are found in the cytoplasm of cells in each layer.

- A none of them
- B 1 only
- C 2 only
- D 3 only
- E 1 and 2 only
- F 1 and 3 only
- G 1, 2 and 3

77 Red blood cells are produced by stem cells in the bone marrow.

A 1 mm^3 sample of blood from a healthy person was found to contain 4×10^6 red blood cells.

The person has a consistent average total blood volume of 0.006 m^3 . Their total red blood cell count does not change and, on average, red blood cells have a lifespan of 100 days.

Which of the following statements is/are correct?

- 1** Red blood cells are phagocytic cells.
- 2** The average rate of production of red blood cells is 1×10^{10} cells per hour.
- 3** The stem cells that produce red blood cells do not have nuclei.

A none of them

B 1 only

C 2 only

D 3 only

E 1 and 2 only

F 1 and 3 only

G 2 and 3 only

H 1, 2 and 3



- 78** Three different methods, X, Y and Z, of controlling pathogens in the human body are compared in the table.

<i>method of controlling the pathogen</i>	<i>affects bacterial pathogens</i>	<i>affects viral pathogens</i>	<i>requires the movement of human cells to have an effect</i>	<i>uses a molecule released from human cells</i>
X	yes	yes	yes	no
Y	yes	no	no	no
Z	yes	yes	no	yes

Which row in the following table is correct?

<i>method of controlling the pathogen</i>			
	X	Y	Z
A	may be stimulated by injections of inactivated pathogen	taking an antibiotic	may work by cells engulfing pathogens
B	may be stimulated by injections of inactivated pathogen	may work by cells engulfing pathogens	taking an antibiotic
C	taking an antibiotic	may be stimulated by injections of inactivated pathogen	may work by cells engulfing pathogens
D	taking an antibiotic	may work by cells engulfing pathogens	may be stimulated by injections of inactivated pathogen
E	may work by cells engulfing pathogens	may be stimulated by injections of inactivated pathogen	taking an antibiotic
F	may work by cells engulfing pathogens	taking an antibiotic	may be stimulated by injections of inactivated pathogen

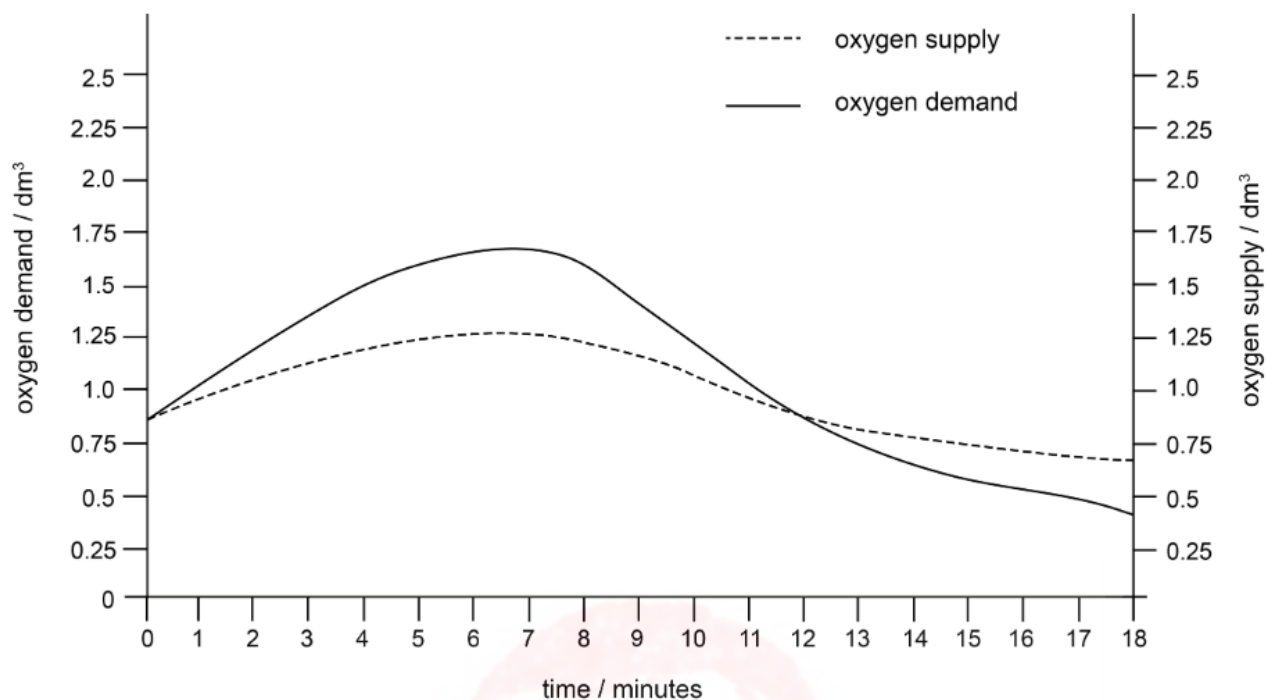
The table shows the concentration of potassium ions in several different locations.

<i>location</i>	<i>concentration of potassium ions</i>
bacterial cell cytoplasm	30 mmol dm ⁻³
mammalian blood plasma	4000 μmol dm ⁻³
mammalian heart cell cytoplasm	1.0 × 10 ² mmol dm ⁻³
sea water	3.0 × 10 ⁴ μmol dm ⁻³
yeast cell cytoplasm	300 mmol dm ⁻³

Which of the following statements is/are correct?

1. A mammalian heart cell needs energy from respiration in order to obtain more potassium ions from blood plasma.
 2. If a yeast cell is placed in sea water then it will lose potassium ions by osmosis.
 3. There is no concentration gradient for potassium ions between a bacterial cell and sea water.
- ☐ none of them
☐ 1 only
☐ 2 only
☐ 3 only
☐ 1 and 2 only
☐ 1 and 3 only
☐ 2 and 3 only
☐ 1, 2 and 3

The graph shows oxygen supply and demand in muscle cells during exercise.



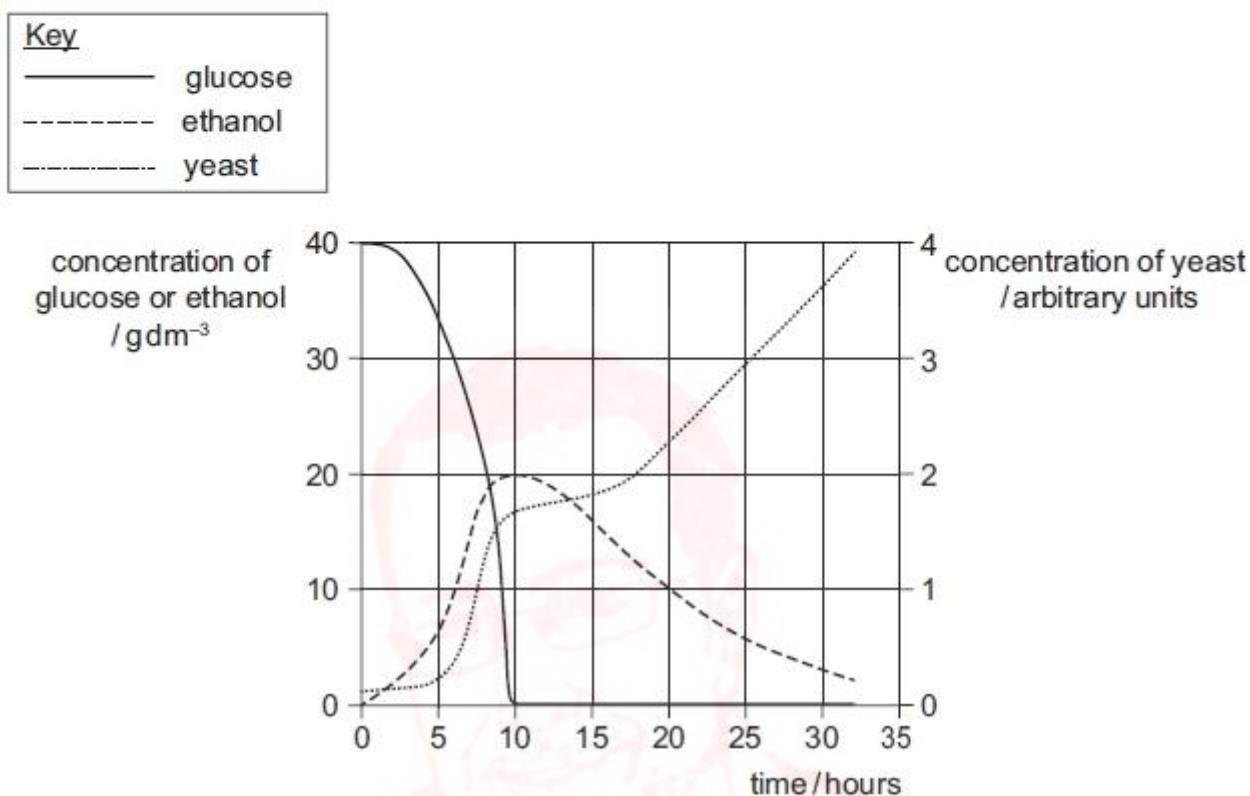
Which statement correctly describes what is happening in the muscle cells between 0 and 11 minutes?

- ☐ Anaerobic respiration only is taking place.
- ☐ More oxygen is being supplied than is required.
- ☐ Aerobic respiration only is taking place.
- ☐ Both anaerobic and aerobic respiration are taking place.

- 72** Even when sufficient oxygen is available, yeast will respire anaerobically using glucose as a substrate. However, if its source of glucose runs out and oxygen is available, yeast can switch to using ethanol as a substrate, which it uses to respire aerobically.

A sample of yeast was added to 100 cm³ glucose solution in an open flask.

The contents of the flask were monitored over 32 hours and the results are shown in the graph.

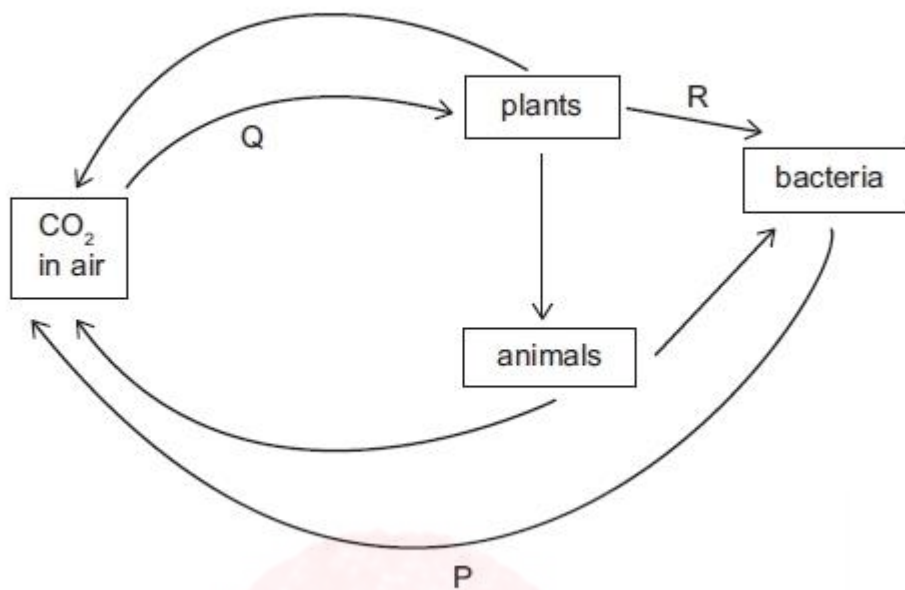


Which of the following statements are correct?

- 1 Carbon dioxide would be produced in the flask at all times throughout the observation period, regardless of whether the yeast was respiring aerobically or anaerobically.
- 2 The yeast was respiring using ethanol as the only substrate for 22 hours.
- 3 The yeast started respiring anaerobically from the start of the observation period.
- 4 The yeast used an average of 4 g glucose per hour for the first 10 hours.

- A 1, 2 and 3 only
- B 1, 2 and 4 only
- C 1, 3 and 4 only
- D 2, 3 and 4 only
- E 1, 2, 3 and 4

- 72** The diagram shows some chemical processes involved in the carbon cycle. Three of these multi-stage processes are labelled P, Q and R.



Which of the following statements is/are correct?

- 1 P requires the presence of mitochondria.
- 2 Overall, Q releases heat.
- 3 R is sensitive to changes in pH and temperature.

- A none of them
- B 1 only
- C 2 only
- D 3 only
- E 1 and 2 only
- F 1 and 3 only
- G 2 and 3 only
- H 1, 2 and 3

- 68** A person ran on a treadmill for 360 seconds. Their rates of aerobic and anaerobic respiration were measured at the start and at the end of the time. The table shows the results.

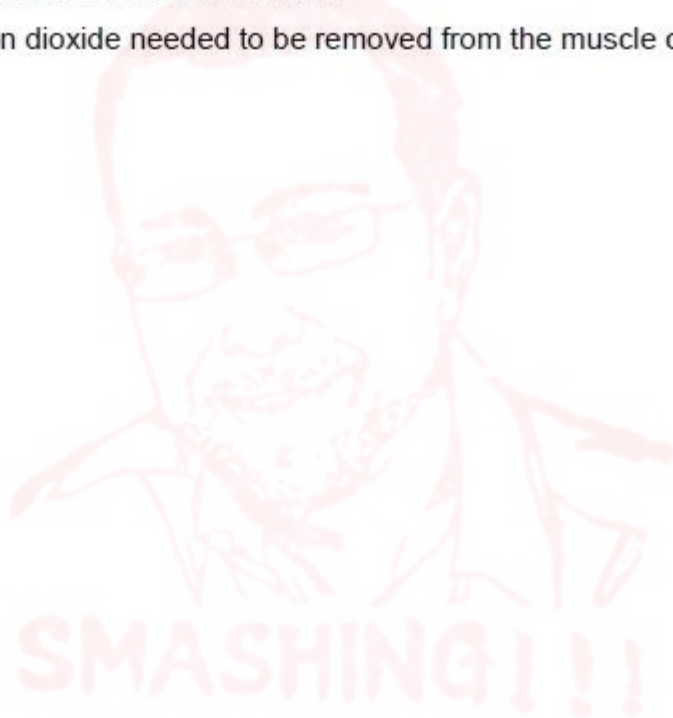
	time = 0 seconds	time = 360 seconds
<i>rate of aerobic respiration</i> /arbitrary units	1.01	5.77
<i>rate of anaerobic respiration</i> /arbitrary units	0.01	3.67

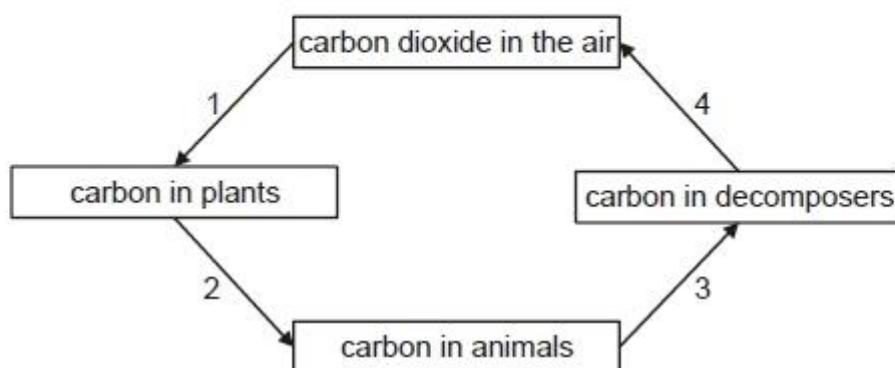
Physiological changes occurred in the person during this time.

Which of the following statements is/are correct during the 360 seconds?

- 1 There was an increase in pH that caused a change in the shape of the respiratory enzyme's active sites.
- 2 Part of the increase in the rate of cellular respiration may have been due to a temperature increase in the muscles.
- 3 More carbon dioxide needed to be removed from the muscle cells.

- A none of them
- B 1 only
- C 2 only
- D 3 only
- E 1 and 2 only
- F 1 and 3 only
- G 2 and 3 only
- H 1, 2 and 3

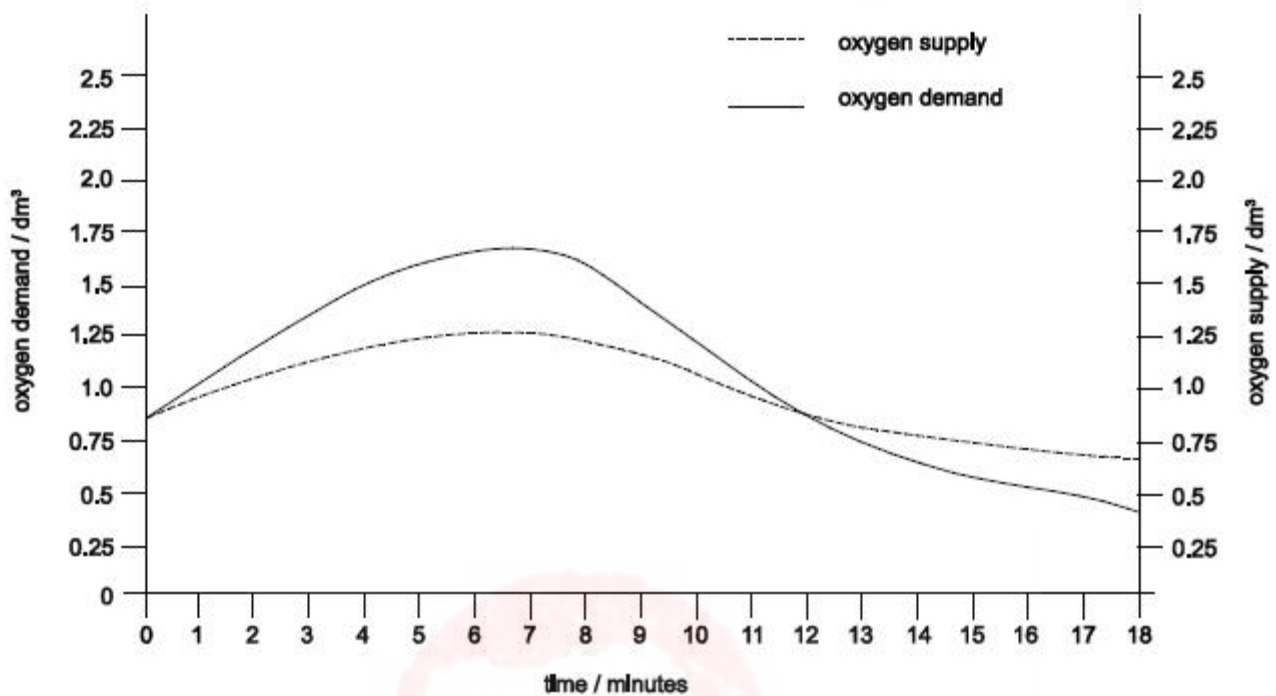




Which row shows the numbered processes that use digestive or respiratory enzymes?

	<i>process or processes that involve digestive enzymes</i>	<i>process or processes that involve respiratory enzymes</i>
A	1 only	2 and 3 only
B	2 only	1 and 4 only
C	3 only	2 and 4 only
D	4 only	2 and 3 only
E	2 and 3 only	1 only
F	3 and 4 only	2 only
G	1 and 4 only	3 only
H	2 and 3 only	4 only

62 The graph shows oxygen supply and demand in muscle cells during exercise.

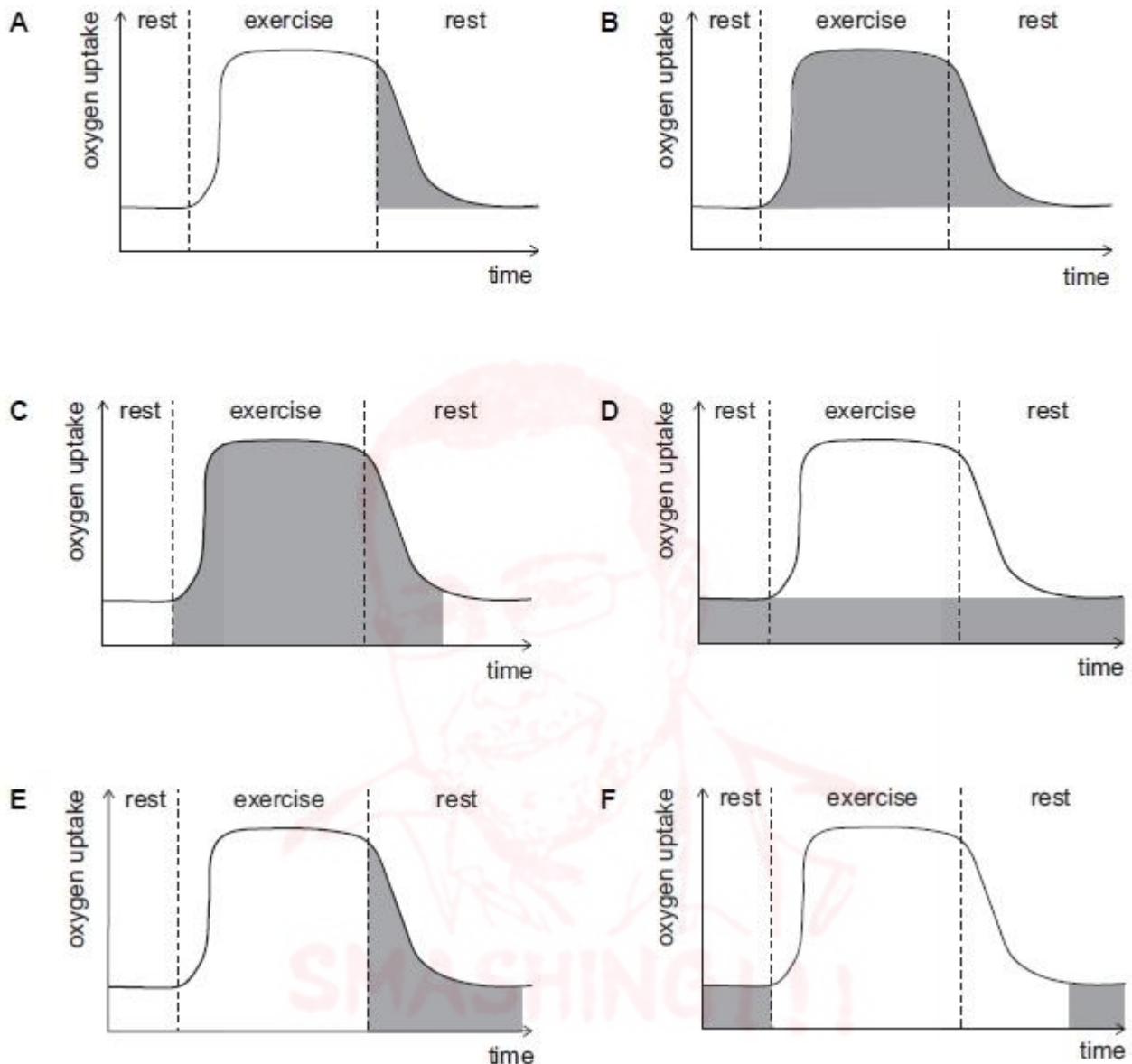


Which statement correctly describes what is happening in the muscle cells between 0 and 11 minutes?

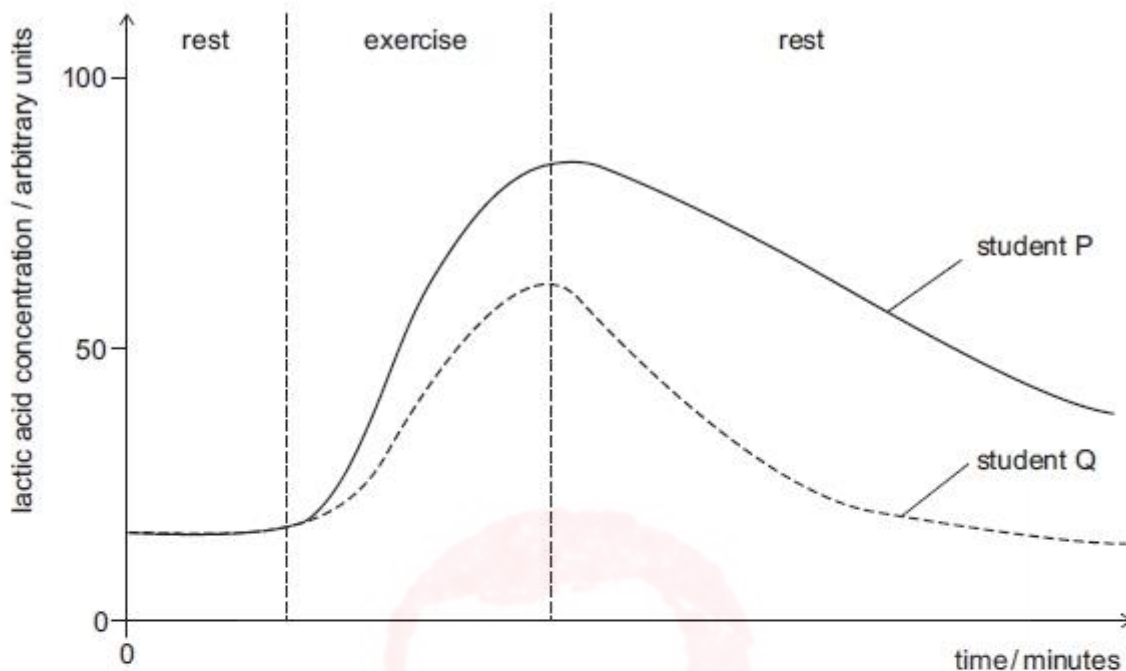
- A Anaerobic respiration only is taking place.
- B More oxygen is being supplied than is required.
- C Aerobic respiration only is taking place.
- D Both anaerobic and aerobic respiration are taking place.

69 The graphs below show the oxygen uptake before, during and after a period of strenuous physical exercise.

Which shaded area correctly represents the additional oxygen taken in to repay the oxygen debt acquired through anaerobic respiration?



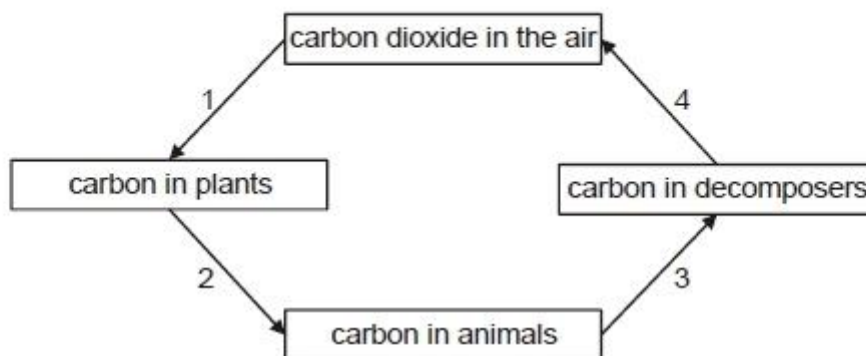
- 55 The graph shows the concentration of lactic acid in the blood of two students at rest, then carrying out the same level of exercise for 15 minutes, and then at rest again.



Which of the following statements correctly describe(s) the two students?

- 1 Student P's oxygen debt is repaid much quicker than student Q's.
 - 2 Student P has a lower oxygen debt than student Q.
 - 3 Student P has a higher level of fitness than student Q.
- A none of them
 B 1 only
 C 2 only
 D 3 only
 E 1 and 2 only
 F 1 and 3 only
 G 2 and 3 only
 H 1, 2 and 3

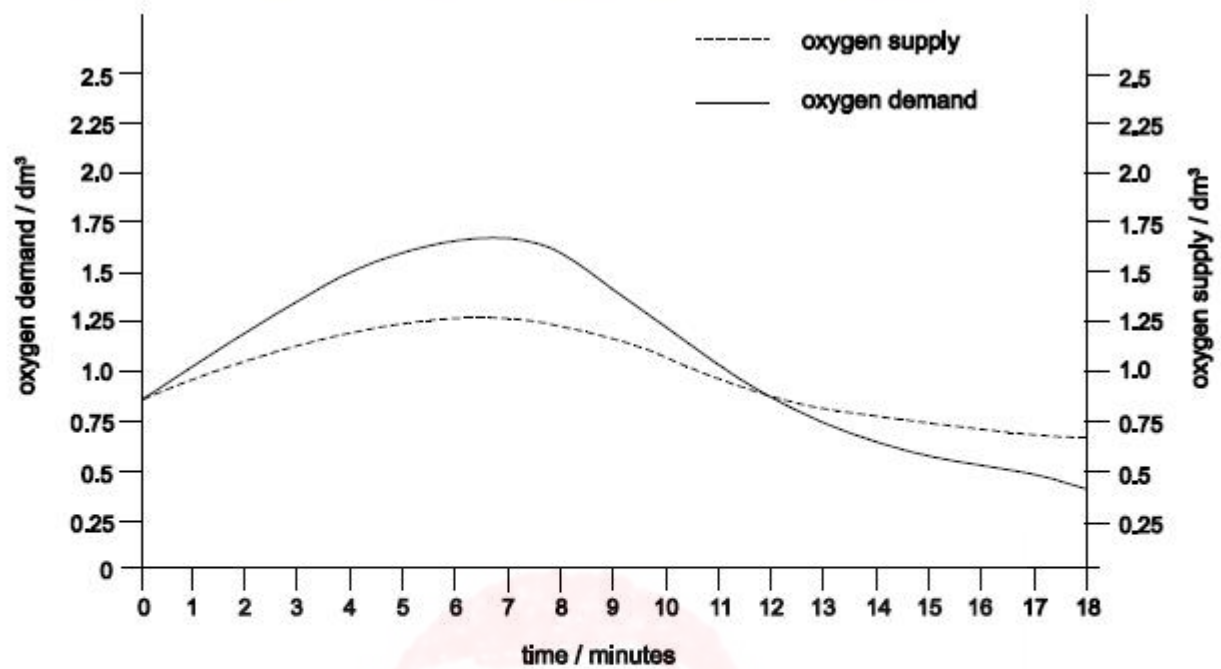
67 The diagram shows part of the carbon cycle.



Which row shows the numbered processes that use digestive or respiratory enzymes?

	<i>process or processes that involve digestive enzymes</i>	<i>process or processes that involve respiratory enzymes</i>
A	1 only	2 and 3 only
B	2 only	1 and 4 only
C	3 only	2 and 4 only
D	4 only	2 and 3 only
E	2 and 3 only	1 only
F	3 and 4 only	2 only
G	1 and 4 only	3 only
H	2 and 3 only	4 only

56 The graph shows oxygen supply and demand in muscle cells during exercise.

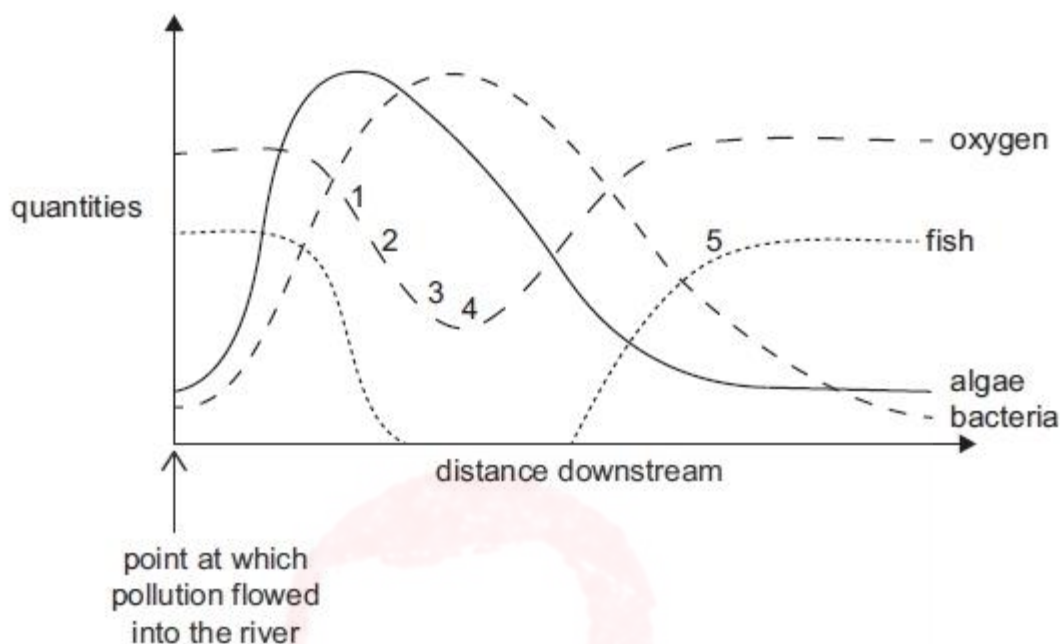


Which statement correctly describes what is happening in the muscle cells between 0 and 11 minutes?

- A Anaerobic respiration only is taking place.
- B More oxygen is being supplied than is required.
- C Aerobic respiration only is taking place.
- D Both anaerobic and aerobic respiration are taking place.

70 The graph shows how a number of factors vary with the distance down a river, after a source of pollution flowed in.

(Assume the oxygen concentration is changing only based on the species present in the river.)



Which one of the statements below can be correctly concluded from the graph?

- A At point 1, the oxygen concentration is decreasing because of increased anaerobic respiration.
- B At point 2, the oxygen concentration is decreasing because high numbers of algae are photosynthesising.
- C At point 3, the oxygen concentration is decreasing because bacteria are using up more oxygen than the algae are producing.
- D At point 4, the number of bloodworms and sludgeworms will be lowest because they lack oxygen.
- E At point 5, fish numbers increase because there is less competition with algae for oxygen.

68 A healthy human is running a race over a distance of 1500 metres as fast as possible.

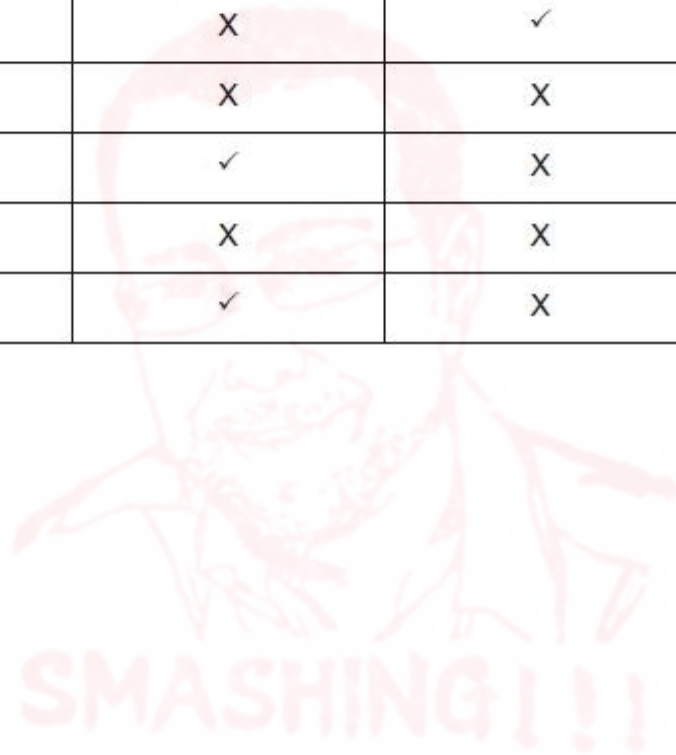
Which row shows molecules that would be in a higher concentration in a vein carrying blood away from an actively contracting leg muscle of the runner compared to an artery carrying blood to the capillaries in the muscle?

Key

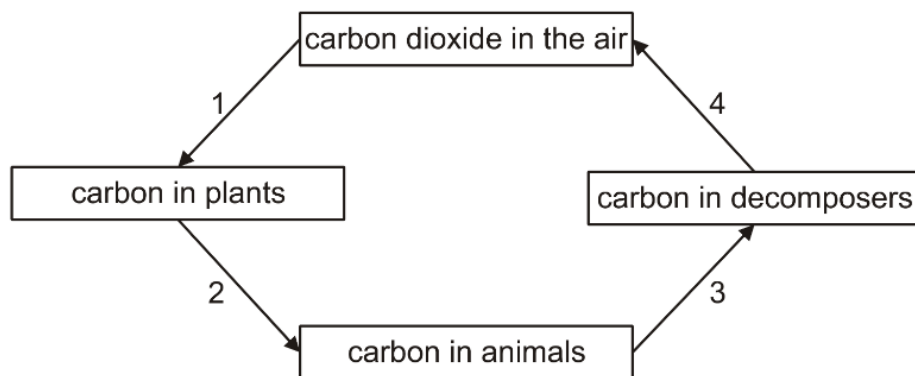
✓ higher

X not higher

	<i>glucose</i>	<i>carbon dioxide</i>	<i>lactic acid</i>
A	✓	✓	✓
B	X	✓	✓
C	X	X	✓
D	X	X	X
E	✓	✓	X
F	✓	X	X
G	X	✓	X



The diagram shows part of the carbon cycle.

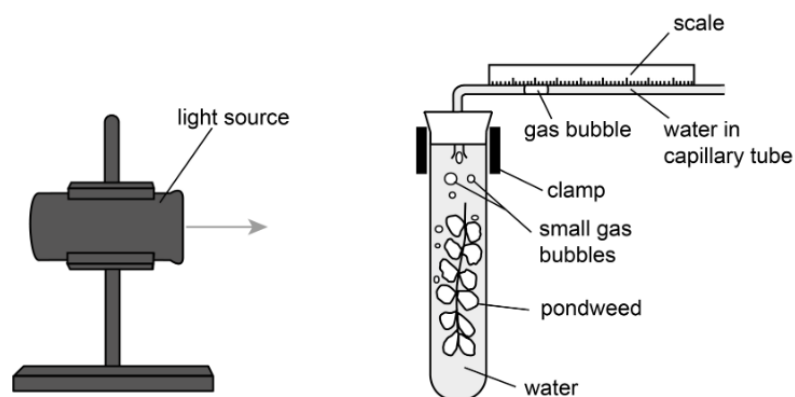


Which row shows the numbered processes that use digestive or respiratory enzymes?

	<i>process or processes that involve digestive enzymes</i>	<i>process or processes that involve respiratory enzymes</i>
A	1 only	2 and 3 only
B	2 only	1 and 4 only
C	3 only	2 and 4 only
D	4 only	2 and 3 only
E	2 and 3 only	1 only
F	3 and 4 only	2 only
G	1 and 4 only	3 only
H	2 and 3 only	4 only

- ☐ A
- ☐ B
- ☐ C
- ☐ D
- ☐ E
- ☐ F
- ☐ G
- ☐ H

A student investigated the endothermic reaction of photosynthesis in pondweed. The student set up the apparatus as shown in the diagram.



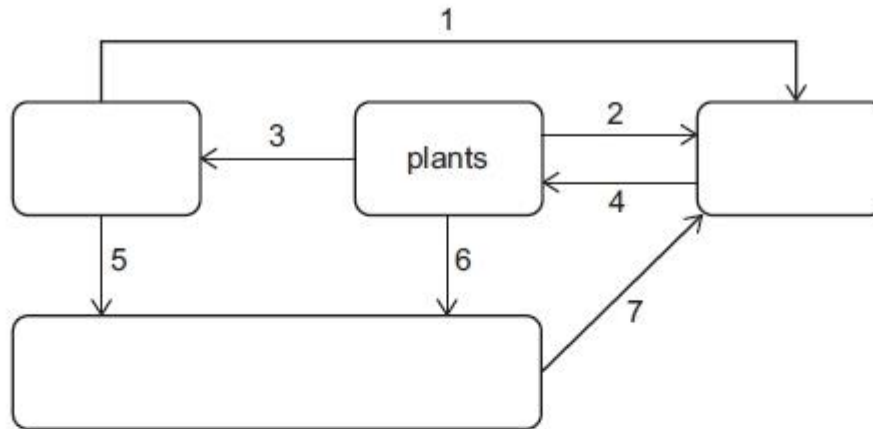
The experiment was left for 5 minutes and the distance moved by the gas bubble along a capillary tube of 2 mm diameter was recorded. Using these values, the rate of gas production is $2\pi \text{ mm}^3$ per minute.

Which row of the table is correct?

	<i>total distance moved by the gas bubble during the experiment / mm</i>	<i>reason why the reaction is described as endothermic</i>	<i>observations if the light source was moved further from the pondweed</i>
A	0.5	the reaction releases energy	the gas bubble moves more slowly to the right
B	0.5	the reaction takes in energy	the gas bubble moves more slowly to the left
C	2.0	the reaction releases energy	the gas bubble moves more slowly to the left
D	2.0	the reaction releases energy	the gas bubble moves more slowly to the right
E	2.5	the reaction takes in energy	the gas bubble moves more slowly to the left
F	2.5	the reaction takes in energy	the gas bubble moves more slowly to the right
G	10.0	the reaction releases energy	the gas bubble moves more slowly to the left
H	10.0	the reaction takes in energy	the gas bubble moves more slowly to the right

- ☐ A
☐ B
☐ C
☐ D
☐ E
☐ F
☐ G
☐ H

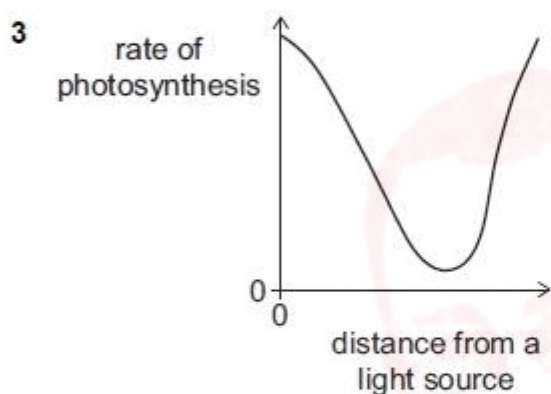
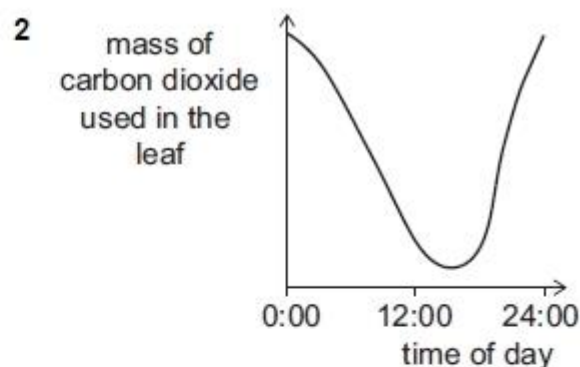
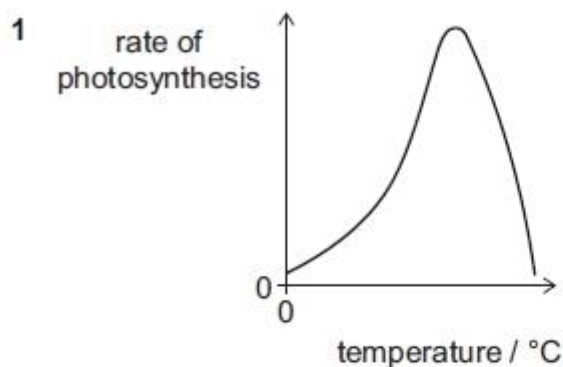
73 The diagram represents part of the carbon cycle.



Which of the arrows represent processes resulting in at least one organic product (contains carbon and hydrogen)?

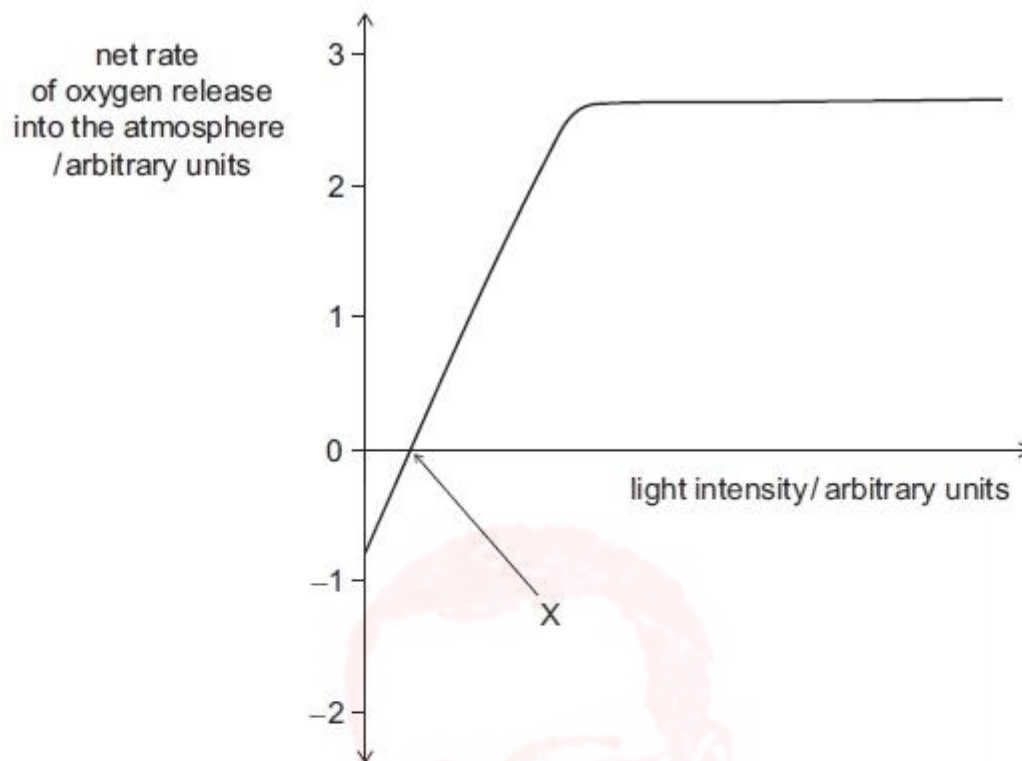
- A 3 only
- B 4 only
- C 5 and 6 only
- D 1, 2 and 7 only
- E 3, 5 and 6 only
- F 1, 2, 3 and 4 only
- G 3, 4, 5 and 6 only
- H 1, 2, 3, 4, 5, 6 and 7

62 Which of the following graphs could describe processes taking place in the leaf of an oak tree in the presence of light?



- A none of them
- B 1 only
- C 2 only
- D 3 only
- E 1 and 2 only
- F 1 and 3 only
- G 2 and 3 only
- H 1, 2 and 3

- 79 The graph shows the effect of increasing light intensity on the net rate at which a plant releases oxygen into the atmosphere.



Which of the following could explain why the net rate of oxygen release at point X is zero?

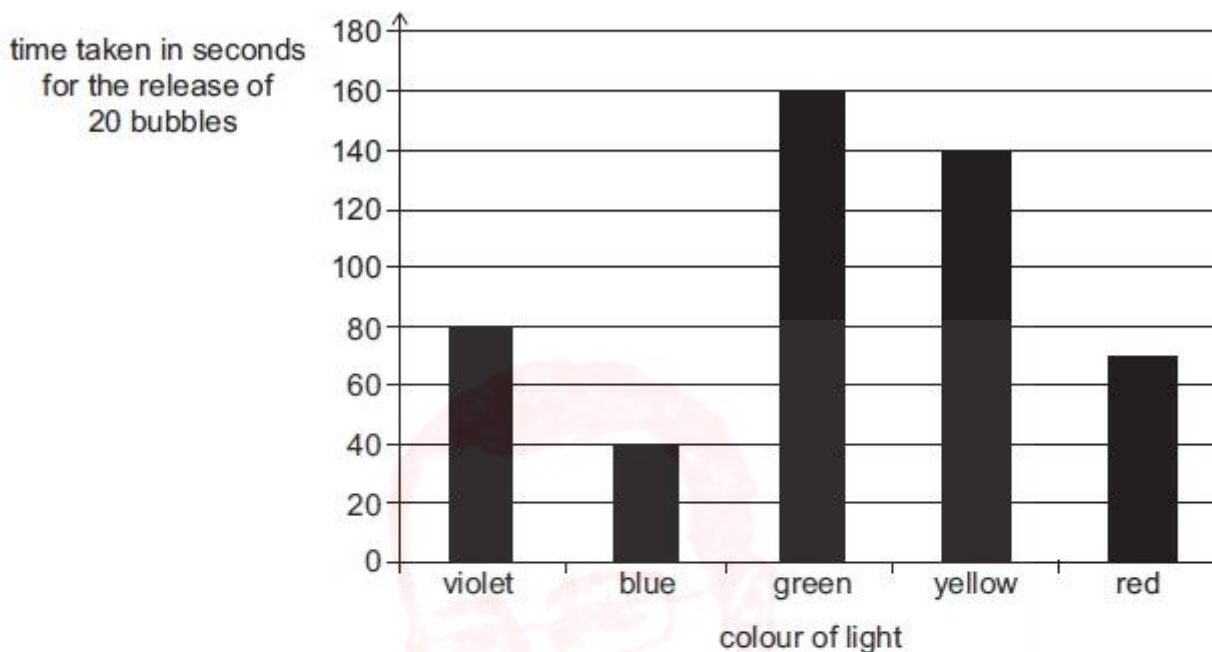
- 1 The light intensity is too low to produce oxygen through photosynthesis.
- 2 All of the stomata will be closed at this light intensity, preventing the release of oxygen.
- 3 The rate of oxygen release from photosynthesis is equal to the rate of oxygen use in respiration.

- A none of them
- B 1 only
- C 2 only
- D 3 only
- E 1 and 2 only
- F 1 and 3 only
- G 2 and 3 only
- H 1, 2 and 3

75 Different samples of the same pond plant were kept underwater and exposed to five different colours of light at the same light intensity.

All other variables were kept constant.

The time taken for the plant to release 20 bubbles was recorded. The results are shown in the chart.



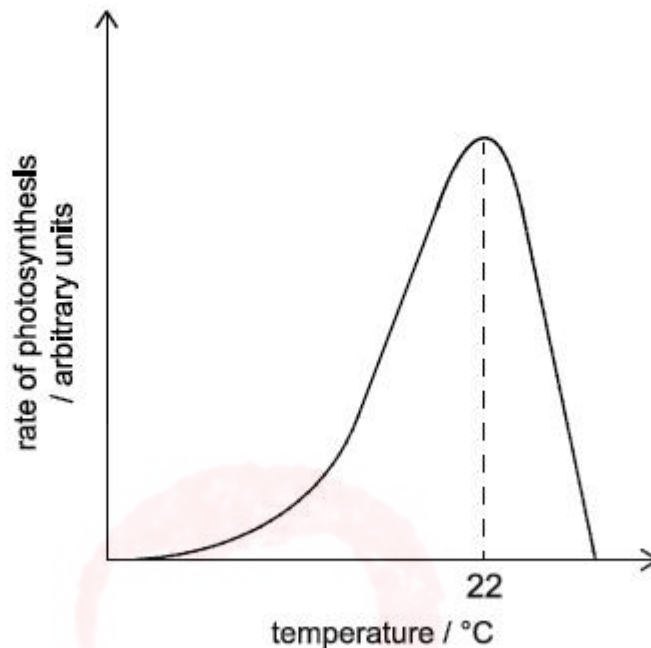
Which of the following conclusions is/are correct?

- 1 This pond plant photosynthesises fastest when exposed to green light.
- 2 When exposed to any of these colours of light, this pond plant would release only oxygen.
- 3 When exposed to blue light, this pond plant produces 30 bubbles per minute.

- A 1 only
- B 2 only
- C 3 only
- D 1 and 2 only
- E 1 and 3 only
- F 2 and 3 only
- G 1, 2 and 3

64 A student carried out an experiment to investigate the effect of temperature on the rate of photosynthesis. All of the other variables were kept constant.

The graph shows the results obtained.



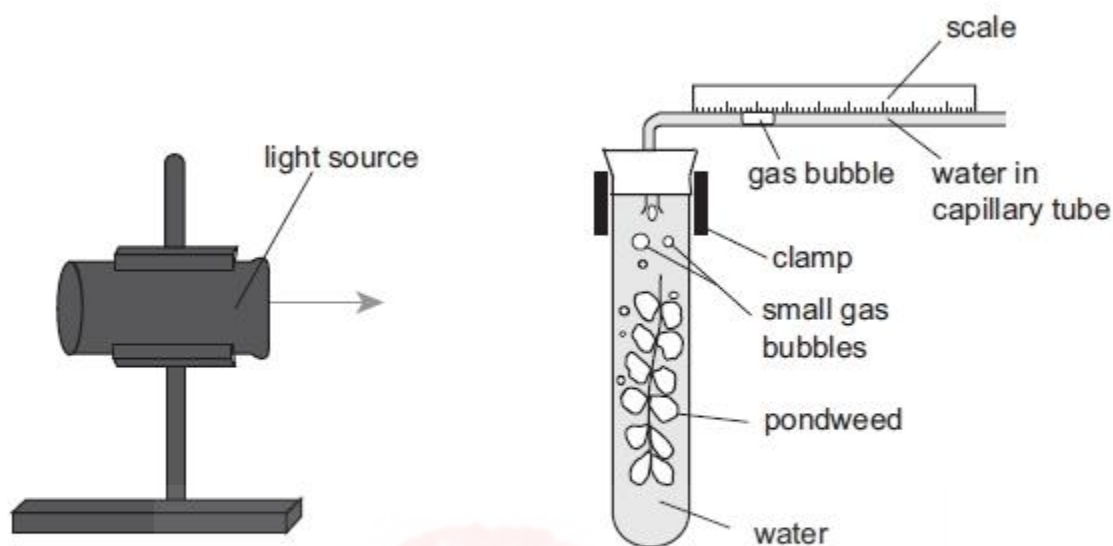
The student considered the graph and made the following conclusions.

- 1 Up to 22 °C temperature is limiting the rate of photosynthesis.
- 2 At temperatures higher than 22 °C not all of the enzymes work so the rate of photosynthesis drops.
- 3 As the temperature increases across the temperature range studied, the rate of photosynthesis increases due to increased kinetic energy.

Which of the student's conclusions is/are correct?

- A none of them
- B 1 only
- C 2 only
- D 3 only
- E 1 and 2 only
- F 1 and 3 only
- G 2 and 3 only
- H 1, 2 and 3

- 73** A student investigated the endothermic reaction of photosynthesis in pondweed. The student set up the apparatus as shown in the diagram.

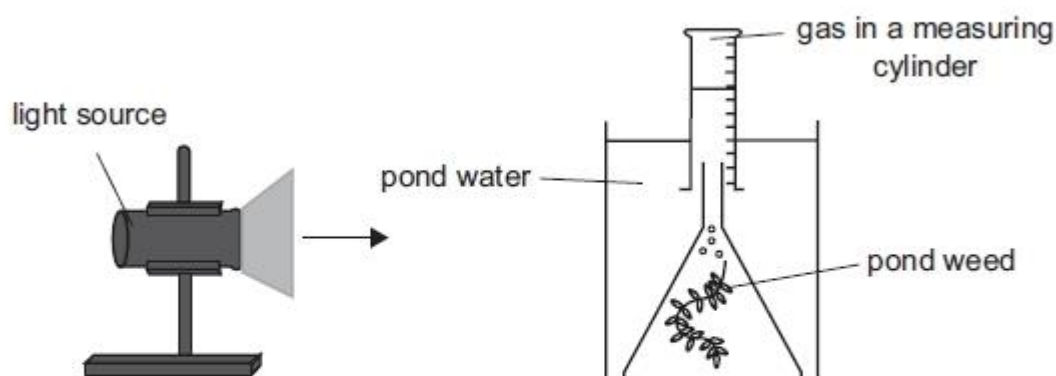


The experiment was left for 5 minutes and the distance moved by the gas bubble along a capillary tube of 2 mm diameter was recorded. Using these values, the rate of gas production is $2\pi\text{mm}^3$ per minute.

Which row of the table is correct?

	<i>total distance moved by the gas bubble during the experiment / mm</i>	<i>reason why the reaction is described as endothermic</i>	<i>observations if the light source was moved further from the pondweed</i>
A	0.5	the reaction releases energy	the gas bubble moves more slowly to the right
B	0.5	the reaction takes in energy	the gas bubble moves more slowly to the left
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D	2.0	the reaction releases energy	the gas bubble moves more slowly to the right
E	2.5	the reaction takes in energy	the gas bubble moves more slowly to the left
F	2.5	the reaction takes in energy	the gas bubble moves more slowly to the right
G	10.0	the reaction releases energy	the gas bubble moves more slowly to the left
H	10.0	the reaction takes in energy	the gas bubble moves more slowly to the right

- 63 A student set up an experiment to measure the rate of photosynthesis, as shown in the diagram.



Data was collected and plotted on a graph.

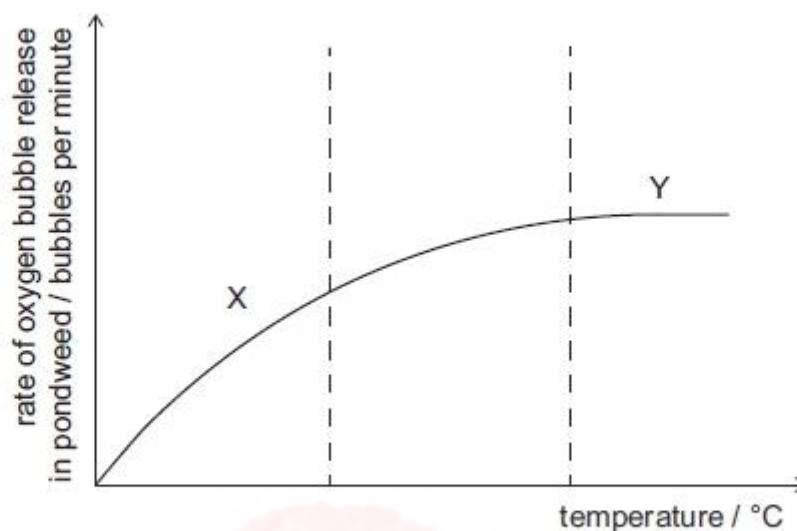
If plotted, which of the following variables would give a gradient that is directly proportional to the rate of photosynthesis?

(All other variables were kept constant.)

	<i>x-axis</i>	<i>y-axis</i>
1	time	volume of CO ₂ released
2	time	number of gas bubbles released per minute
3	volume of oxygen released	time

- A none of them
- B 1 only
- C 2 only
- D 3 only
- E 1 and 2 only
- F 1 and 3 only
- G 2 and 3 only
- H 1, 2 and 3

- 67 A student investigated the rate of oxygen bubble release from a pondweed plant at different temperatures. The rates are shown below, with two sections of the graph marked X and Y. In each investigation all other factors were kept constant.



Which of the following statements about sections X and Y is/are correct?

- 1 In section X, the kinetic energy of the reaction molecules is increasing with increasing temperature.
- 2 In section Y, temperature is the factor which limits that rate of oxygen production.
- 3 In section Y, the plant's enzymes may have denatured.
- 4 Section Y represents the plant's maximum possible rate of oxygen production under any conditions.

- A 1 only
B 2 only
C 3 only
D 4 only
E 1 and 2 only
F 1 and 4 only
G 2 and 3 only
H 3 and 4 only

- 67 Three different coloured leaves were collected: a dark green leaf, a light green leaf and a yellow leaf. Each leaf had 16 discs of 1 cm diameter cut from it.

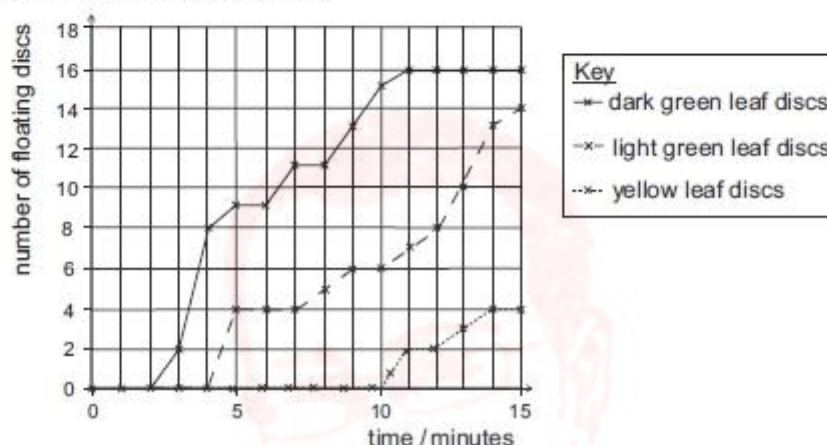
The discs were treated with sodium hydrogen carbonate solution to replace all the air from the spaces within the leaf. Sodium hydrogen carbonate solution is a source of carbon dioxide.

To start the experiment, each group of discs was then placed in a beaker of sodium hydrogen carbonate. At the beginning of the experiment all of the discs sank.

Each beaker was illuminated for 30 minutes by being placed 10 cm in front of a lamp that provided the same wavelengths of light as sunlight. It was observed that some of the leaf discs floated. The number of floating leaf discs was counted every minute for 15 minutes.

The results are shown in the graph.

(All other variables were kept constant.)



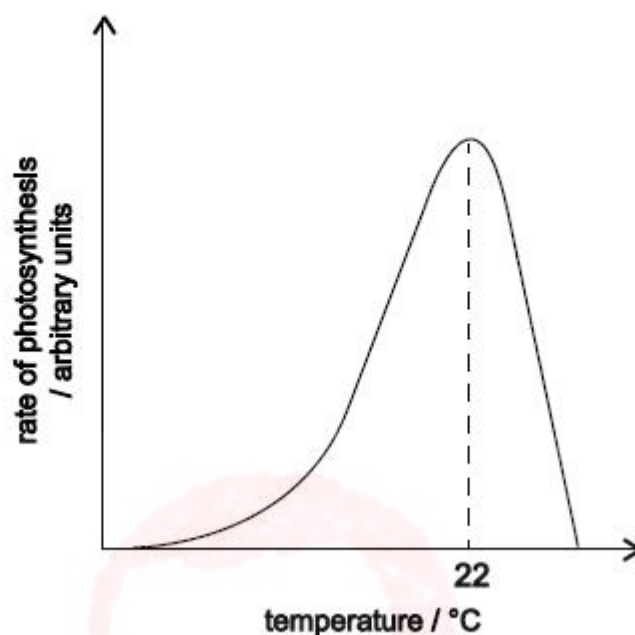
Which of the following statements is/are correct?

- 1 The average rate of photosynthesis was highest in the darkest leaves.
- 2 At 5 minutes 25% of the light green discs remained at the bottom of the beaker.
- 3 The reciprocal of the time taken for a quarter of the discs of a particular colour to float can be a measure of the relative rate of photosynthesis.

- A none of them
 B 1 only
 C 2 only
 D 3 only
 E 1 and 2 only
 F 1 and 3 only
 G 2 and 3 only
 H 1, 2 and 3

58 A student carried out an experiment to investigate the effect of temperature on the rate of photosynthesis. All of the other variables were kept constant.

The graph shows the results obtained.



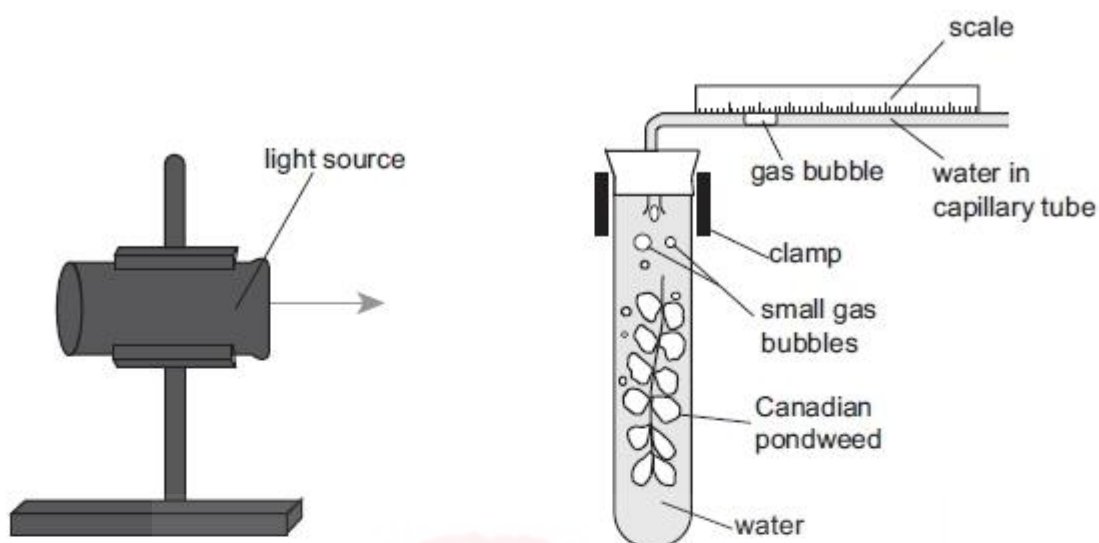
The student considered the graph and made the following conclusions.

- 1 Up to 22°C temperature is limiting the rate of photosynthesis.
- 2 At temperatures higher than 22°C not all of the enzymes work so the rate of photosynthesis drops.
- 3 As the temperature increases across the temperature range studied, the rate of photosynthesis increases due to increased kinetic energy.

Which of the student's conclusions is/are correct?

- A 1 only
- B 2 only
- C 3 only
- D 1 and 2 only
- E 1 and 3 only
- F 2 and 3 only
- G 1, 2 and 3

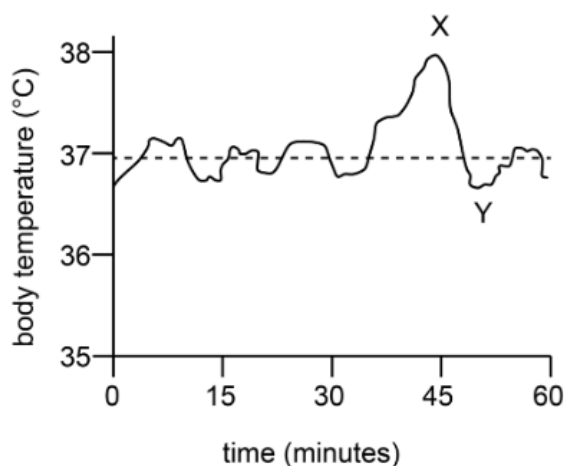
- 61 The diagram shows the apparatus used by a student to carry out an investigation into the rate of photosynthesis in pondweed.



The student measured the distance the gas bubble moved along the capillary tube in 3 minutes as 16 mm. The student calculated the volume of gas produced using the distance moved and the diameter of the capillary tube which was 1.0 mm. After 3 minutes the rate of gas production is reduced.

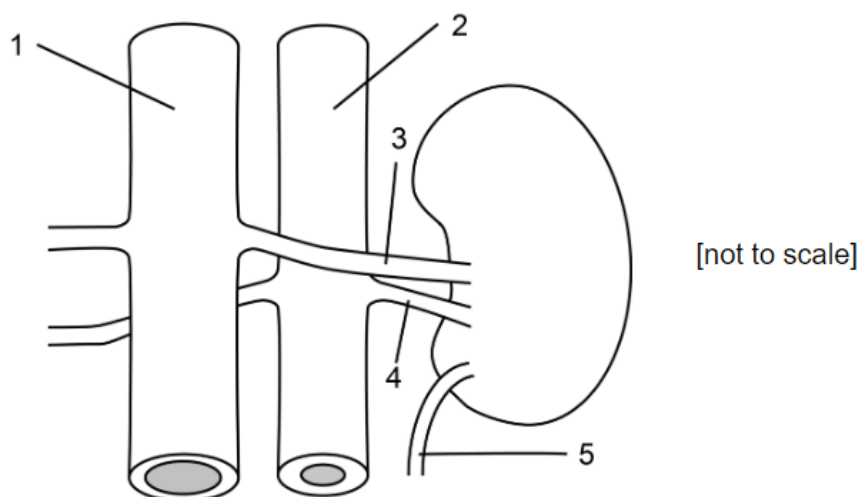
Which row represents the correct statements for this experiment?

	<i>volume of gas produced / mm³</i>	<i>reason for reduction in rate of gas production after 3 minutes</i>
A	4π	all enzyme active sites are occupied
B	4π	carbon dioxide concentration is too low
C	16π	carbon dioxide concentration is too low
D	16π	photosynthesis enzymes denatured
E	16.5π	carbon dioxide concentration is too low
F	16.5π	photosynthesis enzymes denatured
G	34π	all enzyme active sites are occupied
H	34π	photosynthesis enzymes denatured



Which of the following could have caused the temperature change between X and Y?

1. Homeostasis causing more sweat production.
 2. The temperature control centre in the brain causing hairs on the skin to stand up on end.
 3. The temperature control centre in the brain causing less blood to flow near the skin's surface.
- ☐ none of them
- ☐ 1 only
- ☐ 2 only
- ☐ 3 only
- ☐ 1 and 2 only
- ☐ 1 and 3 only
- ☐ 2 and 3 only
- ☐ 1, 2 and 3

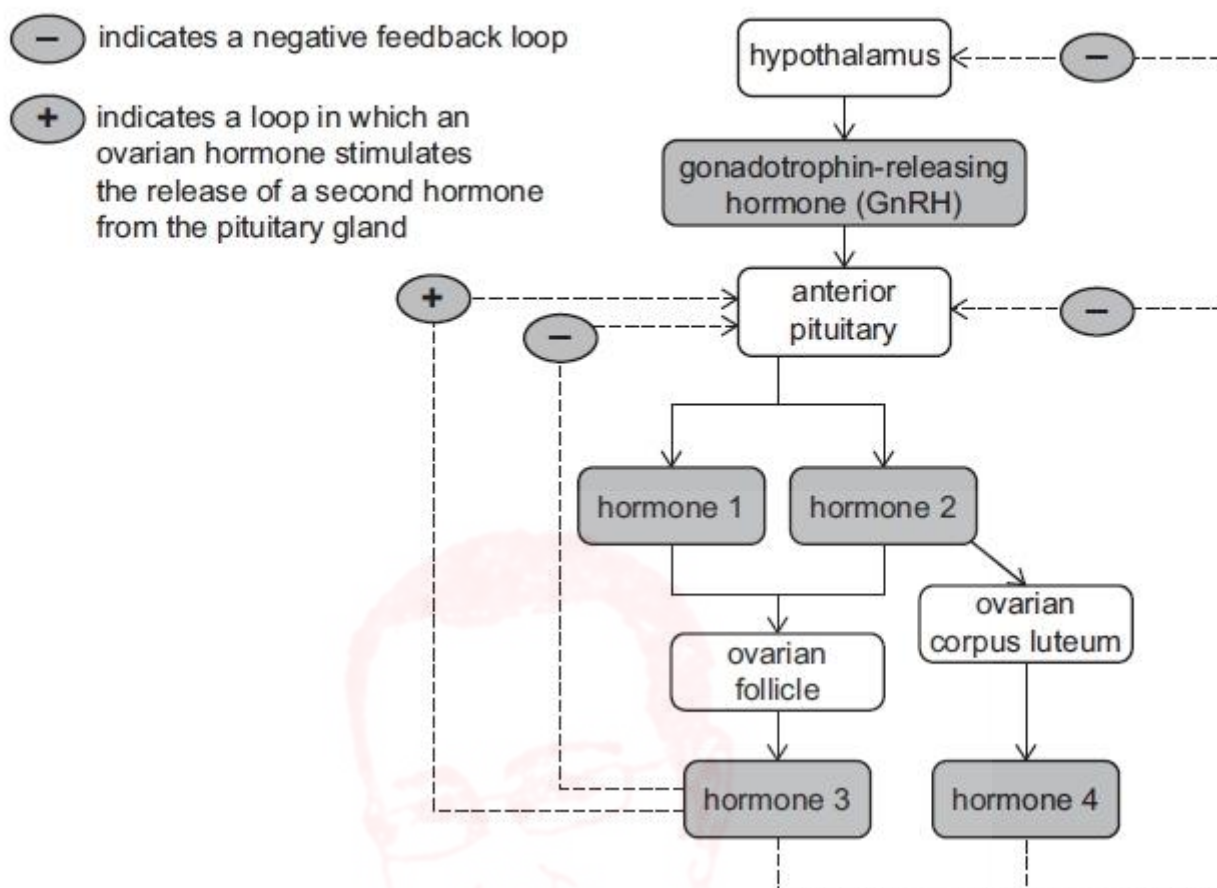


Which row correctly identifies the vessels along with the concentration of urea they contain?

	<i>lowest concentration of urea</i>	<i>highest concentration of urea</i>
A	1 is the aorta	2 is the vena cava
B	1 is the vena cava	2 is the aorta
C	3 is the renal artery	5 is the urethra
D	3 is the renal vein	5 is the ureter
E	4 is the renal vein	5 is the ureter
F	4 is the renal artery	5 is the urethra

- ☐ A
☐ B
☐ C
☐ D
☐ E
☐ F

70 The diagram shows a flow chart representing the hormonal activity associated with the menstrual cycle.

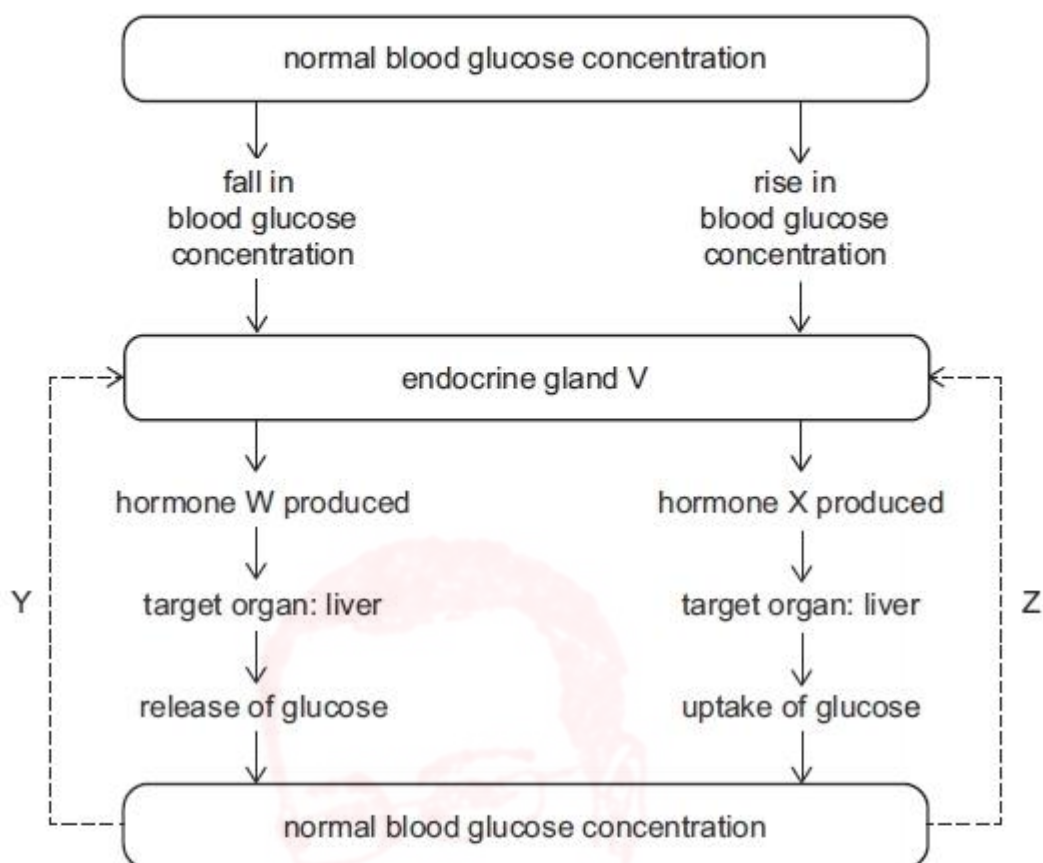


Which of the following statements about the menstrual cycle is/are correct?

- 1 Hormone 1 stimulates follicle maturation and the release of hormone 3 from the ovarian follicle.
- 2 Hormone 4 maintains the uterus lining.
- 3 At the end of the menstrual cycle the levels of hormone 1 and hormone 2 will reach their highest point and then decrease, leading to menstruation.

- A none of them
 B 1 only
 C 2 only
 D 3 only
 E 1 and 2 only
 F 1 and 3 only
 G 2 and 3 only
 H 1, 2 and 3

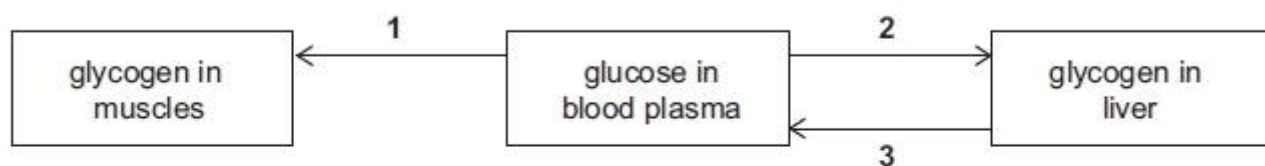
72 The diagram summarises the homeostatic control of blood glucose concentration.



Which row is correct?

	<i>gland V</i>	<i>hormone W</i>	<i>hormone X</i>	<i>process Y</i>	<i>process Z</i>
A	pancreas	adrenaline	insulin	nervous response	nervous response
B	pancreas	glucagon	insulin	negative feedback	negative feedback
C	pancreas	insulin	glucagon	negative feedback	negative feedback
D	pancreas	insulin	glucagon	nervous response	negative feedback
E	pituitary	adrenaline	ADH	negative feedback	nervous response
F	pituitary	ADH	glucagon	nervous response	negative feedback
G	pituitary	ADH	insulin	nervous response	nervous response
H	pituitary	glucagon	insulin	negative feedback	nervous response

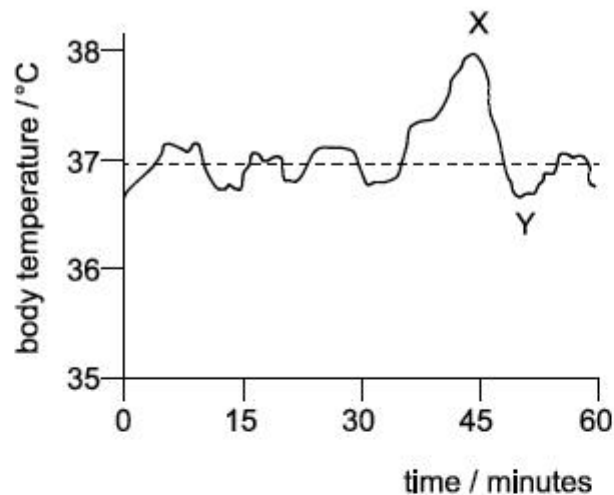
64 The diagram shows some of the ways in which glucose can be added to or removed from blood plasma in humans.



Which hormones stimulate the processes shown by the arrows?

	<i>process 1</i>	<i>process 2</i>	<i>process 3</i>
A	adrenaline	glucagon	insulin
B	adrenaline	adrenaline glucagon	glucagon
C	insulin	adrenaline	glucagon
D	insulin	insulin	adrenaline glucagon
E	glucagon	insulin	glucagon
F	glucagon	glucagon	insulin

71 The graph shows how body temperature of a human varies over a period of 60 minutes.



Which of the following could have caused the temperature change between X and Y?

- 1 Homeostasis causing more sweat production.
- 2 The temperature control centre in the brain causing hairs on the skin to stand up on end.
- 3 The temperature control centre in the brain causing less blood to flow near the skin's surface.

- A none of them
- B 1 only
- C 2 only
- D 3 only
- E 1 and 2 only
- F 1 and 3 only
- G 2 and 3 only
- H 1, 2 and 3

67 The table shows concentrations of substances in blood entering and leaving three different organs of a person:

- kidney
- small intestine
- chambers of the right side of the heart

The blood sample was taken 10 minutes after the person had eaten a carbohydrate-rich meal.

organ	concentration in blood entering the organ			concentration in blood leaving the organ		
	glucose / mg dm ⁻³	oxygen / arbitrary units	urea / mg dm ⁻³	glucose / mg dm ⁻³	oxygen / arbitrary units	urea / mg dm ⁻³
1	9.0	65	3.0	9.0	65	3.0
2	9.0	85	3.0	9.0	70	2.4
3	9.0	85	3.0	12.0	70	3.0

Which row in the following table identifies the organs?

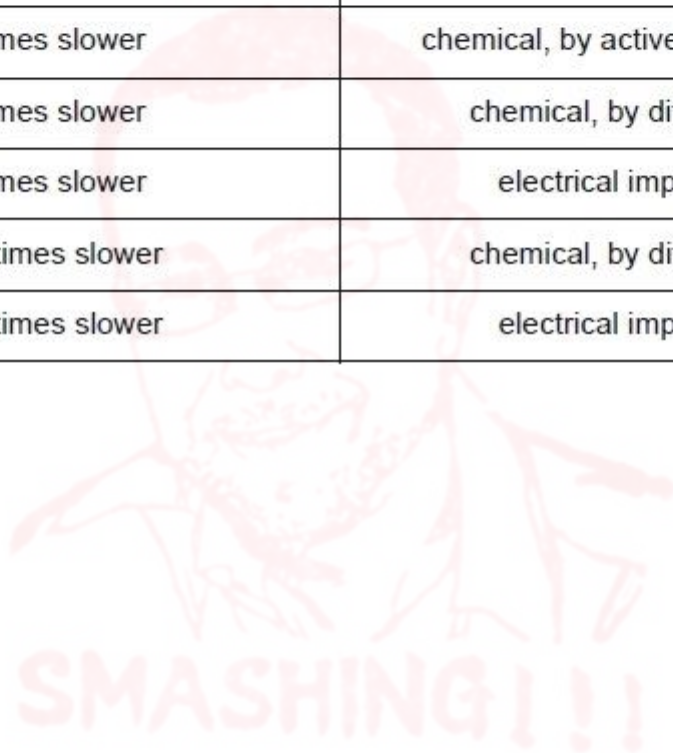
	organ 1	organ 2	organ 3
A	kidney	small intestine	chambers of the right side of the heart
B	kidney	chambers of the right side of the heart	small intestine
C	small intestine	kidney	chambers of the right side of the heart
D	small intestine	chambers of the right side of the heart	kidney
E	chambers of the right side of the heart	small intestine	kidney
F	chambers of the right side of the heart	kidney	small intestine

79 In a mammal, an impulse travels along a neurone of length 45 cm in 3.0×10^{-3} seconds.

Transmission across the synapse to another neurone takes 4.0×10^{-10} seconds. The synapse has a width of 20 nm.

Which row correctly compares the speed of transmission across the synapse with the speed of transmission along the neurone, and what is the method of transmission across the synapse?

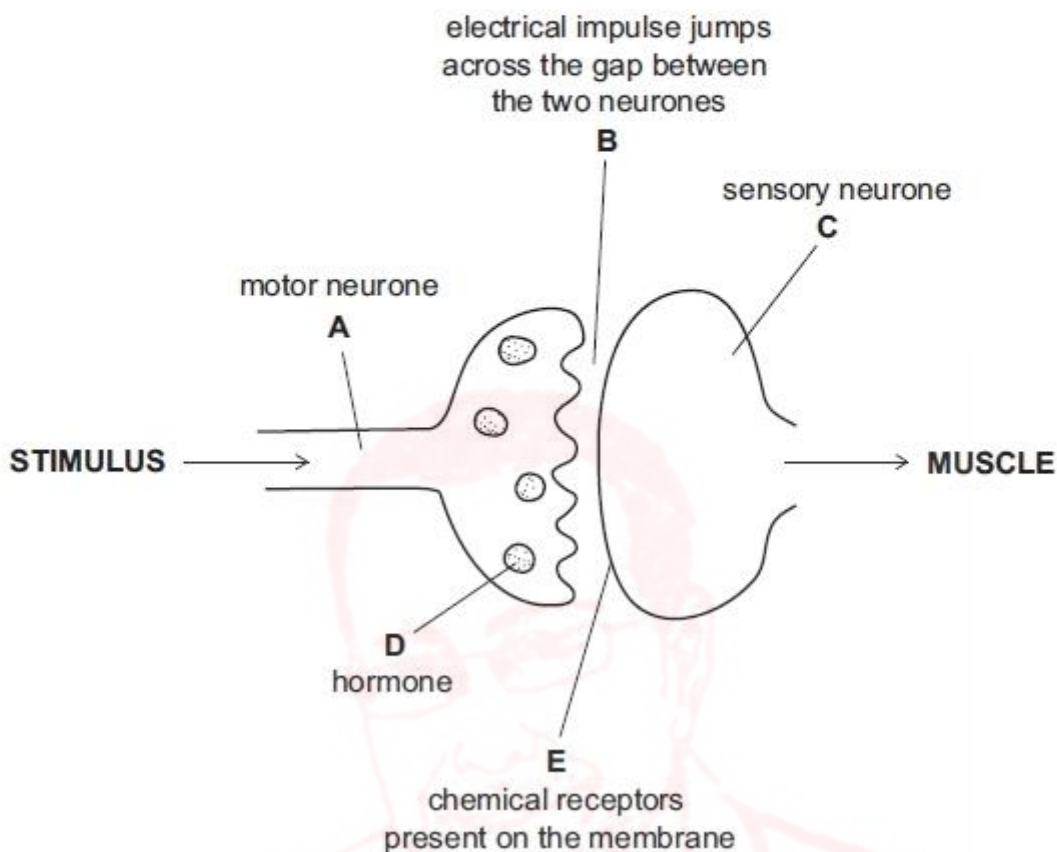
	<i>speed of transmission across the synapse compared to speed of transmission along the neurone</i>	<i>method of transmission across the synapse</i>
A	300 times faster	chemical, by active transport
B	300 times faster	chemical, by diffusion
C	300 times faster	electrical impulse
D	3 times slower	chemical, by active transport
E	3 times slower	chemical, by diffusion
F	3 times slower	electrical impulse
G	300 times slower	chemical, by diffusion
H	300 times slower	electrical impulse



66 When a person touches a hot object, they rapidly pull their hand away as a result of a reflex arc.

The diagram shows a student's drawing of part of this reflex arc.

Which label (A-E) is correct?



64 Which one of the following comparisons is correct?

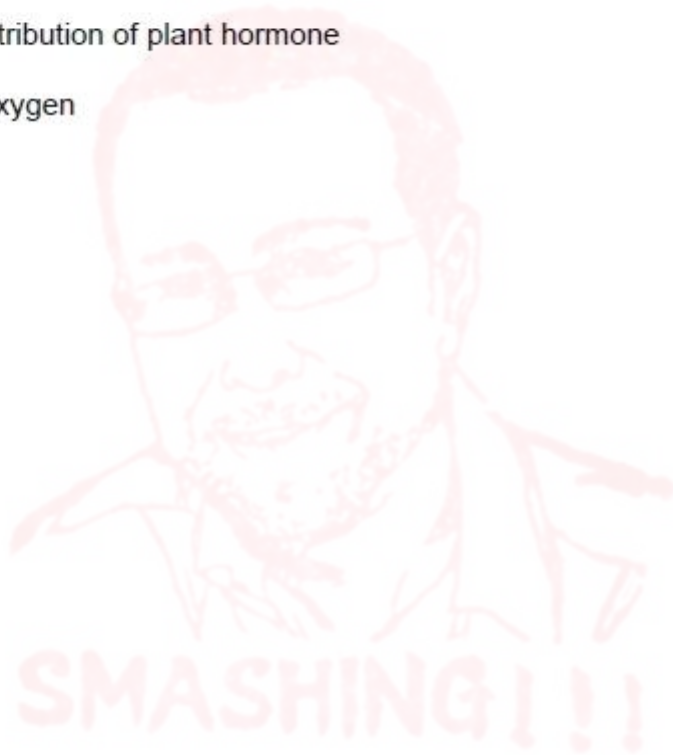
			comparison
A	alveoli	bronchi	both are tissues that are specialised for gas exchange
B	pancreas	ovary	both are organs that function as endocrine glands
C	phloem	xylem	both are organs that transport liquids from leaves to roots in plants
D	sensory neurone	motor neurone	both are tissues that are stimulated by a relay neurone
E	small intestine	trachea	both are organs that have tissues with cilia

56 Which one of the following statements about cells or tissues is correct?

- A Any adult stem cells can naturally give rise to all tissue.
- B Endocrine glands secrete enzymes into the bloodstream.
- C Embryonic stem cells divide by meiosis to form all cell types.
- D Receptor cells send chemical impulses along neurones.
- E The stomach wall contains a tissue that enables movement of food.

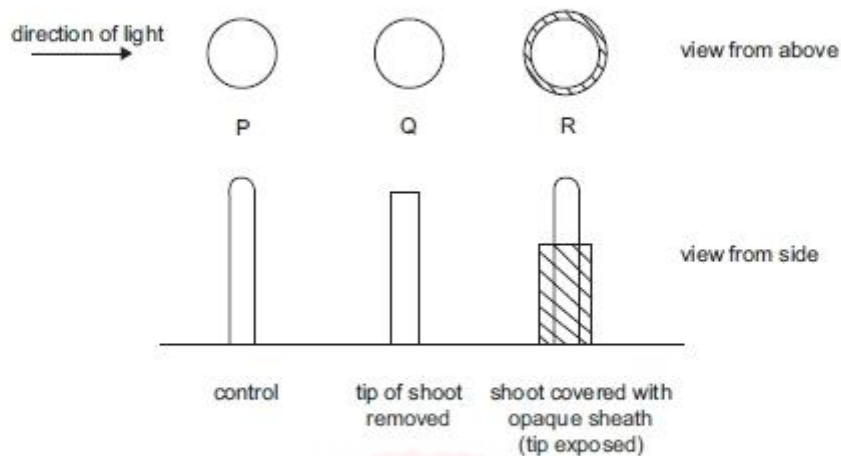
61 Which of the following conditions is/are required by the cells near the tip of a plant shoot in order for the tip to grow towards light from one direction?

- 1 sufficient glucose
 - 2 uneven distribution of plant hormone
 - 3 sufficient oxygen
- A none of them
 - B 1 only
 - C 2 only
 - D 3 only
 - E 1 and 2 only
 - F 1 and 3 only
 - G 2 and 3 only
 - H 1, 2 and 3

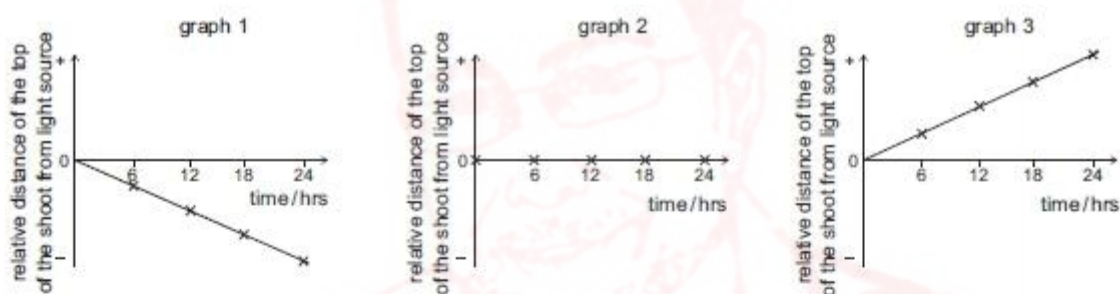


- 69 The diagram shows the start of an experiment on the effect of light direction on young shoots. All of the shoots were growing vertically. All of the shoots were the same distance from the light source. All of the shoots were continually exposed to the light from one side for 24 hours.

(All other variables were kept constant.)



Every six hours, the distance between the light source and the top of each shoot was measured. The distance from the light source relative to the position at the start of the experiment was plotted on the following graphs.

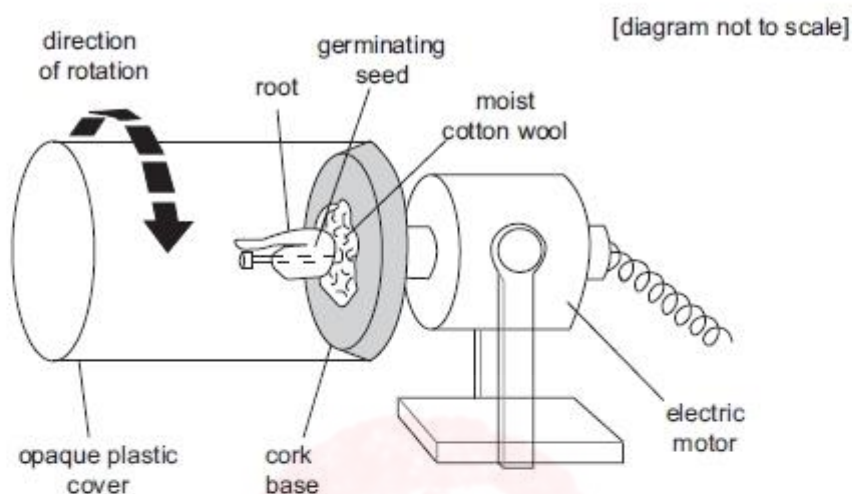


Which row represents the responses of the shoots to the light over 24 hours?

	P	Q	R
A	1	2	1
B	1	3	1
C	1	3	2
D	2	1	3
E	2	2	1
F	3	1	3
G	3	2	2

- 63 Young plant roots show a similar positive response to the direction of gravity as their shoots do to the direction of light.

A clinostat, shown in the diagram, can be used to counter the effects of gravity on a plant. It has a motor which slowly rotates the plant. The cover is opaque to prevent light affecting the direction of root growth.



Two clinostats were set up using identical seedlings for two days:

Clinostat 1, with the motor running
Clinostat 2, with the motor stationary

In which direction would the root grow in each clinostat?

Key

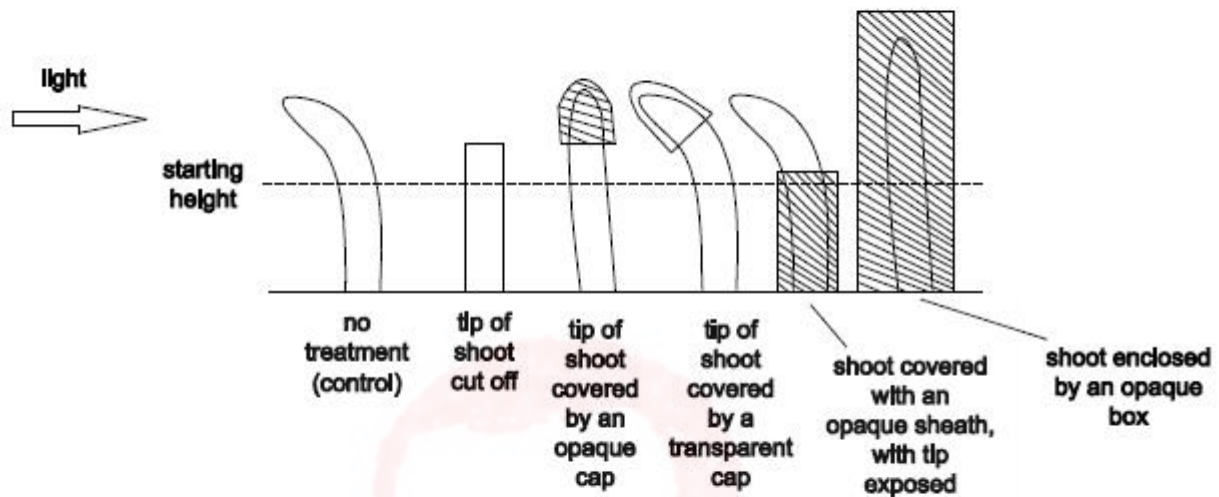
↓ ↓ downwards
↑ ↑ upwards
← ← horizontally

	results for clinostat 1	results for clinostat 2
A	↓ ↓	↑ ↑
B	↓ ↓	← ←
C	↓ ↓	↓ ↓
D	↑ ↑	← ←
E	↑ ↑	↓ ↓
F	← ←	↑ ↑
G	← ←	↓ ↓
H	← ←	← ←

64 An experiment was set up to show the effect of light on shoots subject to the same intensity of light after 24 hours and various different treatments.

At the start of the experiment all the shoots were the same height and all were growing vertically.

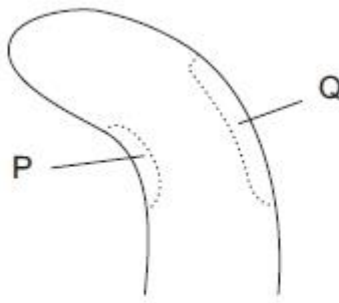
The diagram shows the results of an experiment on the effect of light on young shoots, after 24 hours of exposure to the light.



Which of the following statements about the results is/are correct?

- 1 All uncovered shoots showed a positive phototropic response.
- 2 Covering any part of the shoot prevented a phototropic response.
- 3 Shoots grow taller only when exposed to light.

- A 1 only
- B 2 only
- C 3 only
- D 1 and 2 only
- E 1 and 3 only
- F 2 and 3 only
- G 1, 2 and 3
- H none of them



A student wrote the following statements to explain the growth of this shoot:

- 1 Cells at P are smaller than the cells at Q.
- 2 Concentration of plant hormone is higher at Q than P.
- 3 Unidirectional light has caused a change in the concentration of plant hormone at P.

Which of the student's statements, if any, could be correct?

- A none of them
- B 1 only
- C 2 only
- D 3 only
- E 1 and 2 only
- F 1 and 3 only
- G 2 and 3 only
- H 1, 2 and 3

The karyogram below is a photograph of the chromosomes taken from a single human cell.



Using the karyogram, which of the following statements is/are correct?

1. The karyogram shows no visible mutations.
2. The chromosomes are from a cell taken from a male.
3. The cell used could have been a white blood cell.

Image used with permission of UW Cytogenetics/Wisconsin State Laboratory of Hygiene © Board of Regents of the University of Wisconsin System

- ☐ none of them
- ☐ 1 only
- ☐ 2 only
- ☐ 3 only
- ☐ 1 and 2 only
- ☐ 1 and 3 only
- ☐ 2 and 3 only
- ☐ 1, 2 and 3

In rabbits, there are two alleles concerned with dark pigment in the fur:

- the dominant allele, B, for black colour
- the recessive allele, b, for brown colour

Two male black rabbits of unknown genotype each mated with a different female brown rabbit.

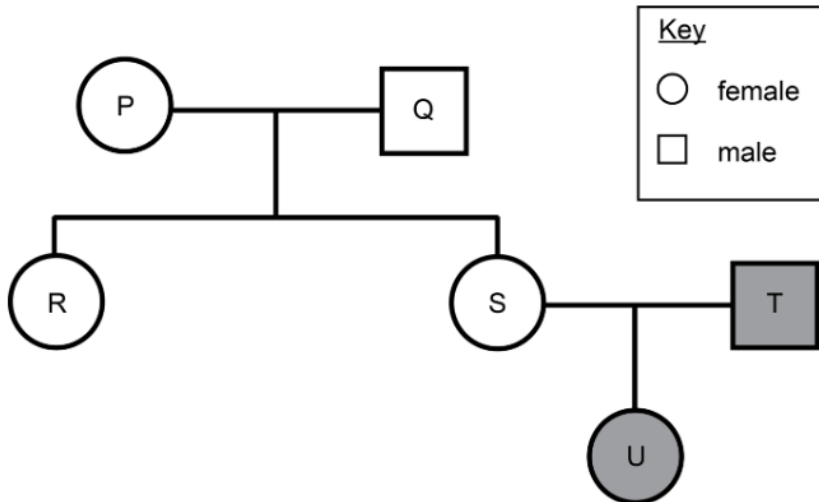
What is the expected proportion of brown offspring if both male rabbits are heterozygous, and what is the expected proportion of brown offspring if only one male rabbit is heterozygous?

	<i>expected proportion of brown offspring</i>	
	<i>if both male rabbits heterozygous</i>	<i>if only one male rabbit heterozygous</i>
A	0.25	0.5
B	0.25	1
C	0.5	0.25
D	0.5	1
E	1	0.25
F	1	0.5

- ☐ A
☐ B
☐ C
☐ D
☐ E
☐ F



The genetic condition represented by the shading is caused by the presence of at least one allele for the condition.



Which of the following are possible reasons why U has the condition?

1. The condition is dominant.
 2. The sperm from T carried the allele for the condition.
 3. A mutation is present in an egg of S.
- ☐ none of them
- ☐ 1 and 2 only
- ☐ 1 and 3 only
- ☐ 2 and 3 only
- ☐ 1, 2 and 3

The sex of a species of fruit fly is determined by the number of X chromosomes relative to the number of non-sex chromosomes (A) in a cell. This is called the X : A ratio.

A fruit fly will be male if $X : A = 0.5 : 1$, and female if $X : A = 1 : 1$

The Y chromosome contains genes necessary for making sperm.

Which row of the table correctly shows the sex of the five fruit flies with different numbers of these chromosomes?

	XAA	XYAA	XXAA	XXYAA	XXYYAA
A	female	female	female	male	male
B	female	female	male	male	male
C	female	male	female	male	female
D	female	male	female	male	male
E	male	female	male	female	female
F	male	female	male	female	male
G	male	male	female	female	female
H	male	male	female	female	male

- ☐ A
- ☐ B
- ☐ C
- ☐ D
- ☐ E
- ☐ F
- ☐ G
- ☐ H



Topic 16 Q# 143/ Cambridge/2024/ESAT/ Biology/ Q# 13 /www.SmashingScience.org/

The table shows information about a human genetic condition called sickle cell anaemia and an infection called malaria. Both sickle cell anaemia and malaria can be fatal.

<i>genotype</i>	<i>phenotype</i>	<i>comment</i>
MM	does not show sickle cell anaemia	can be infected with malaria
Mm	does not show sickle cell anaemia	shows resistance to malaria
mm	shows sickle cell anaemia	shows more resistance to malaria than Mm

Which of the following statements is/are correct?

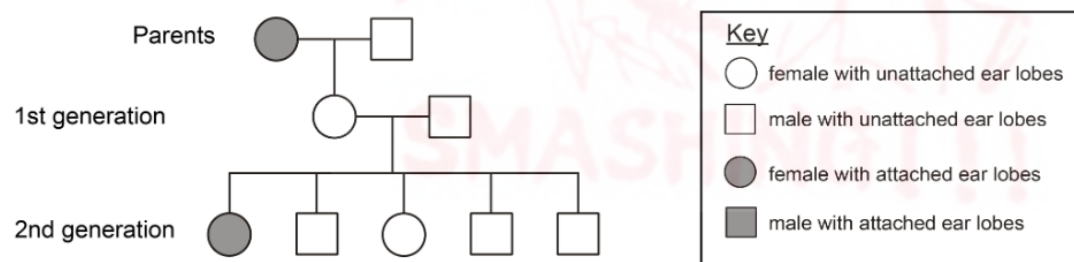
1. In areas without malaria, human populations are likely to have a low number of people with the m allele.
2. In areas with malaria, only those individuals that are heterozygous will be able to pass on their alleles to the next generation.
3. Presence of malaria has caused a mutation of the M allele to the m allele leading to an increased chance of survival in the heterozygous state.

- ☐ none of them
- ☐ 1 only
- ☐ 2 only
- ☐ 3 only
- ☐ 1 and 2 only
- ☐ 1 and 3 only
- ☐ 2 and 3 only
- ☐ 1, 2 and 3

Topic 16 Q# 144/ Cambridge/2024/ESAT/ Biology/ Q# 10 /www.SmashingScience.org/

A person's ear lobes can be attached to the side of their head or unattached. The allele for attached ear lobes is recessive to the allele for unattached ear lobes.

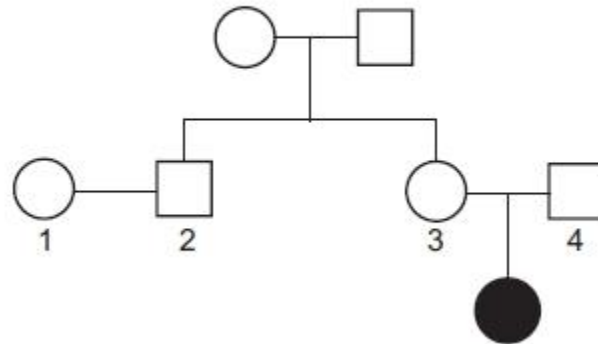
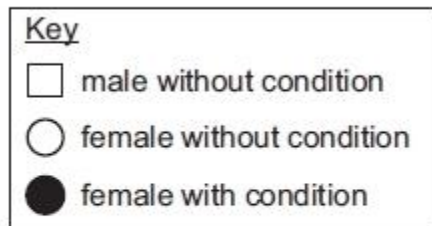
The pedigree diagram below shows the ear lobe attachment in one family.



What is the maximum possible number of heterozygous individuals in this pedigree diagram?

- ☐ 2
- ☐ 3
- ☐ 4
- ☐ 5
- ☐ 6
- ☐ 7
- ☐ 8
- ☐ 9

76 The family tree shows the inheritance of an autosomal recessive genetic condition.



Which of the following statements is/are correct for this family?

- 1 If one cheek cell is collected from each individual, the overall ratio of X chromosomes to Y chromosomes will be 3.67 : 1
- 2 The probability of individual 2 and individual 3 having the same alleles on their X chromosomes is 100%.
- 3 The probability of individual 2 and individual 3 having the same genotype for the condition is 50%.

(Assume no mutations.)

- A none of them
- B 1 only
- C 2 only
- D 3 only
- E 1 and 2 only
- F 1 and 3 only
- G 2 and 3 only
- H 1, 2 and 3

- 68** The table shows details of genetic characteristics of three species of organisms and the genetic crosses carried out with them.

<i>cross</i>	<i>organism</i>	<i>dominant characteristic</i>	<i>recessive characteristic</i>	<i>description of parents in cross</i>	
V	cattle	have horns	hornless	heterozygous horned	× hornless
W	fruit flies	grey-bodied	ebony-bodied	heterozygous grey-bodied	× heterozygous grey-bodied
Y	pea plants	round seeds	wrinkled seeds	wrinkled seeds	× homozygous round seeds

All alleles exhibit simple dominant/recessive relationships.

Which of the following statements is/are correct?

- 1 If two of the offspring from cross V are bred together, three different crosses could result, with three different probabilities of phenotypes in the next generation: 100% hornless, 50% hornless, or 25% hornless.
- 2 The genotypes of the offspring with the dominant characteristic from cross W will be identifiable through their phenotypes.
- 3 A farmer planted seeds collected from the offspring of cross Y. If these seeds grew and produced flowers which were then cross-pollinated with each other, the resulting seeds would yield a crop containing 50% homozygous plants.

- A none of them
- B 1 only
- C 2 only
- D 3 only
- E 1 and 2 only
- F 1 and 3 only
- G 2 and 3 only
- H 1, 2 and 3

- 80 Two parents are heterozygous for a recessive condition that is controlled by a single autosomal gene with one dominant and one recessive allele. They have a daughter who does not display the condition.

This daughter has a child with a heterozygous man.

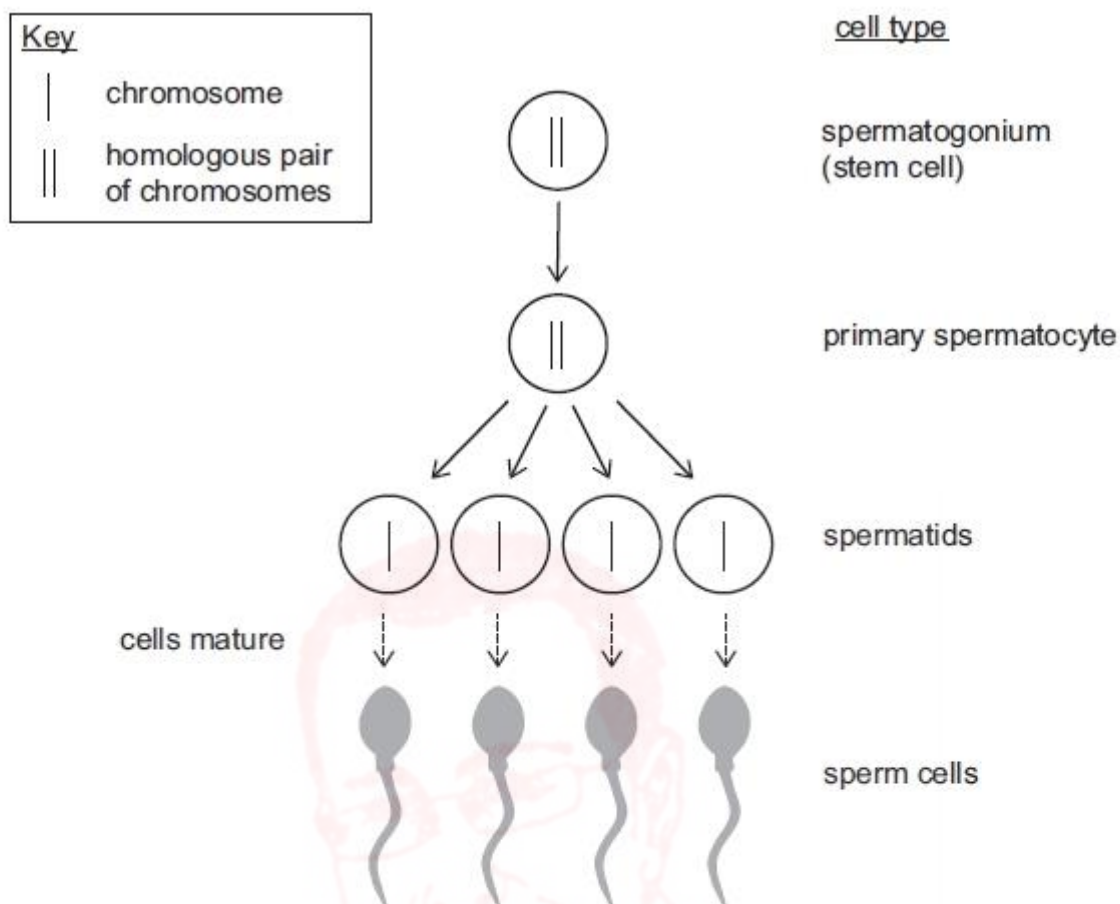
What is the probability that this child displays the condition?

(Assume no mutations.)

- A $\frac{1}{12}$
- B $\frac{1}{8}$
- C $\frac{1}{6}$
- D $\frac{3}{4}$
- E $\frac{11}{12}$



78 The diagram shows part of the process of sperm production in a healthy human male. Only one pair of the 23 pairs of homologous chromosomes is shown.



Which of the following statements is/are correct?

- 1 Gametes are produced from haploid stem cells.
- 2 Upon fertilisation, it is the male gamete that would determine the sex of the offspring.
- 3 DNA in the primary spermatocyte is copied before the spermatids are made.

- A none of them
- B 1 only
- C 2 only
- D 3 only
- E 1 and 2 only
- F 1 and 3 only
- G 2 and 3 only
- H 1, 2 and 3

- 77 Two flies, which were both heterozygous for a trait, mated and all their eggs were collected. The resulting offspring grew into young adult flies.

The trait is controlled by a single gene with one dominant allele and one recessive allele.

Which of the following statements, taken independently, could be correct for the young adult fly population?

- 1 If the presence of two dominant alleles for this trait stops eggs with this genotype from hatching, the genotypic ratio within the young adult fly population would be 1 : 1.
- 2 If the presence of two recessive alleles for this trait produces sterile individuals, all of the young adult fly population will have the same phenotype.
- 3 If the population of young adult flies is small, the phenotypic ratio would be 1 : 2 : 1.

- A none of them
- B 1 only
- C 2 only
- D 3 only
- E 1 and 2 only
- F 1 and 3 only
- G 2 and 3 only
- H 1, 2 and 3



- 67** A cell from a healthy animal was removed. This cell contained four times the mass of DNA when compared to a single gamete from the same animal.

Which of the following statements could be correct?

- 1 The cell was just about to start meiosis.
- 2 The cell was just about to start mitosis.
- 3 The cell had just started meiosis.
- 4 The cell had just started mitosis.

- A 1 only
- B 2 only
- C 1 and 2 only
- D 1 and 3 only
- E 2 and 3 only
- F 2 and 4 only
- G 1, 2, 3 and 4



79 A student compared the properties of different cells from one healthy human.

Which of the following statements is/are correct?

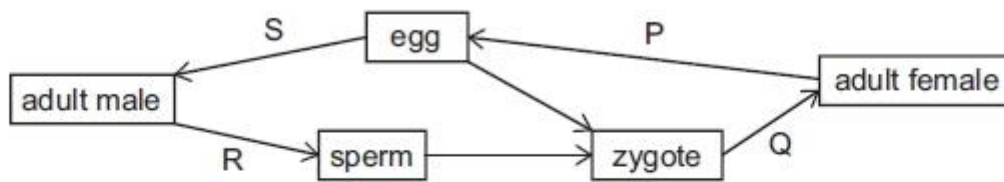
(Assume that no mutations occur.)

- 1 A cheek cell contains the same alleles as an embryonic stem cell.
- 2 A sperm cell contains the same genome as a cheek cell.
- 3 A white blood cell contains the same number of DNA bases as a mature red blood cell.
- 4 An embryonic stem cell produces all of the same proteins as a white blood cell.

- A 1 only
- B 2 only
- C 3 only
- D 4 only
- E 1 and 2 only
- F 1 and 3 only
- G 2 and 4 only
- H 3 and 4 only



78 The diagram shows the life cycle of one species of ant, in which males are haploid and females are diploid.

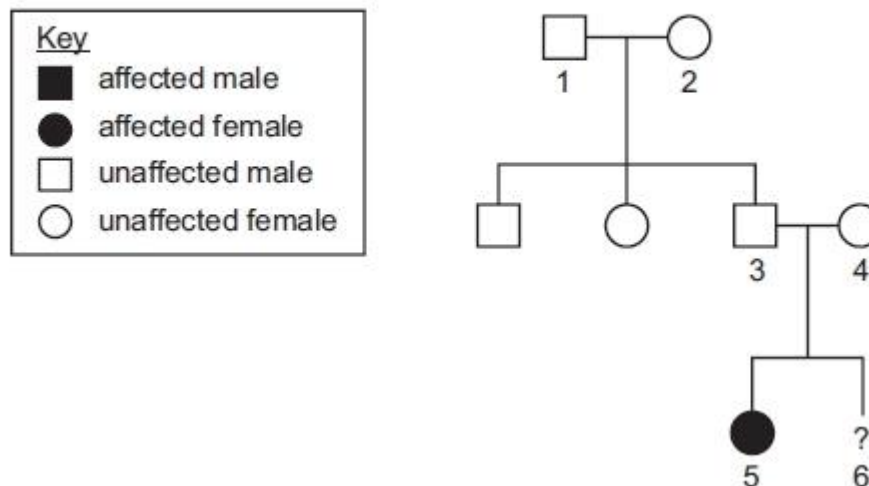


Which of the letters on the diagram represent(s) meiosis?

- A P only
- B Q only
- C R only
- D S only
- E P and Q only
- F P and R only
- G P and S only
- H Q and R only



74 The pedigree diagram shows the inheritance of a phenotypic feature caused by a recessive allele.



What is the probability that individual 6 is an unaffected male?

- A 12.5%
- B 25%
- C 37.5%
- D 50%
- E 62.5%
- F 75%

69 Coat colour variation in a particular population of mice is only affected by one gene with two alleles, R and r. This gene is not on a sex chromosome.

Heterozygous mice have yellow fur. Embryos that are homozygous dominant do not survive.

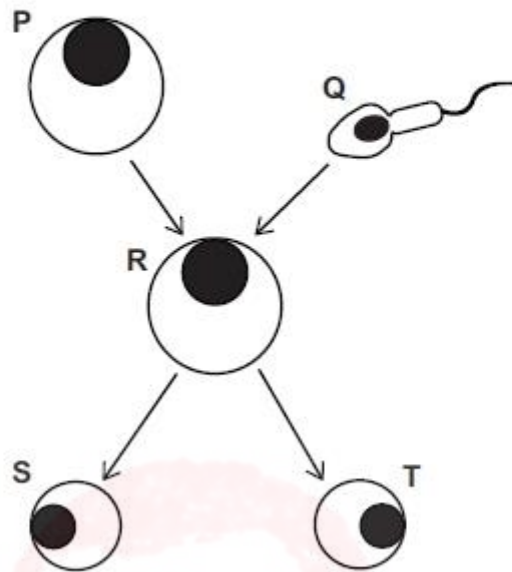
A yellow male and a yellow female mouse were mated several times and a large number of offspring were produced. Some of the offspring were grey in colour and others were yellow.

Assuming that no new mutations have occurred, which of the following is correct?

- A 25% of the live offspring will be grey in colour.
- B All grey mice have a homozygous genotype for coat colour.
- C Offspring with XY chromosomes are all heterozygous for coat colour.
- D The live offspring of a cross between a yellow and a grey mouse will always be yellow.
- E There is a 3 : 1 ratio of dominant to recessive alleles for this gene in the live offspring.

65 The diagram shows two gametes, gamete P and gamete Q, fusing to form cell R in a healthy human. R divides to form two cells, S and T.

S and T grow into two separate individuals.

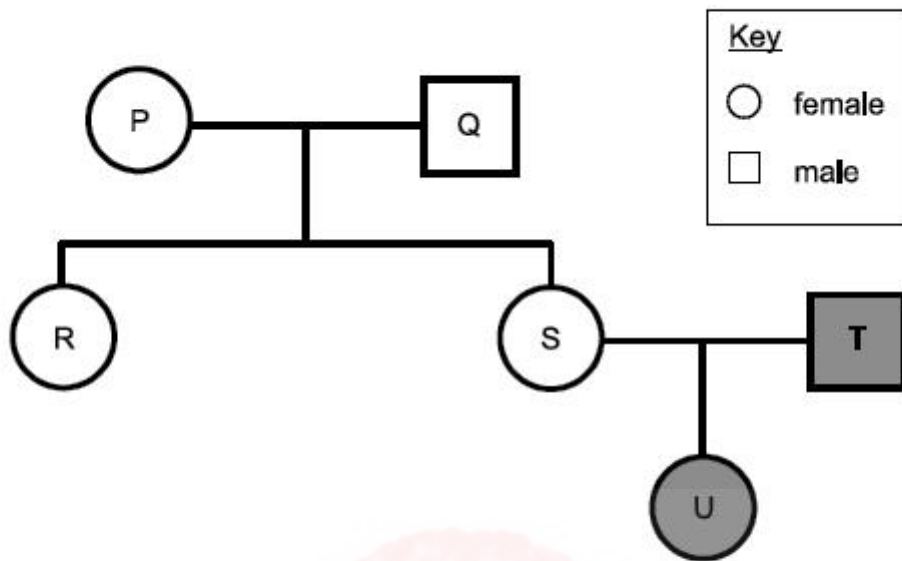


Which of the following statements is/are correct?

- 1 The number of double strands of DNA is the same in gamete P and cell T.
- 2 If gamete Q contains a Y chromosome, then both individuals that grow from cells S and T will be genetically male.
- 3 A mutation in the DNA in cell R before mitosis will always change the phenotype of cell S.

- A none of them
- B 1 only
- C 2 only
- D 3 only
- E 1 and 2 only
- F 1 and 3 only
- G 2 and 3 only
- H 1, 2 and 3

78 The genetic condition represented by the shading is caused by the presence of at least one allele for the condition.



Which of the following are possible reasons why U has the condition?

- 1 The condition is dominant.
- 2 The sperm from T carried the allele for the condition.
- 3 A mutation is present in an egg of S.

- A none of them
- B 1 and 2 only
- C 1 and 3 only
- D 2 and 3 only
- E 1, 2 and 3

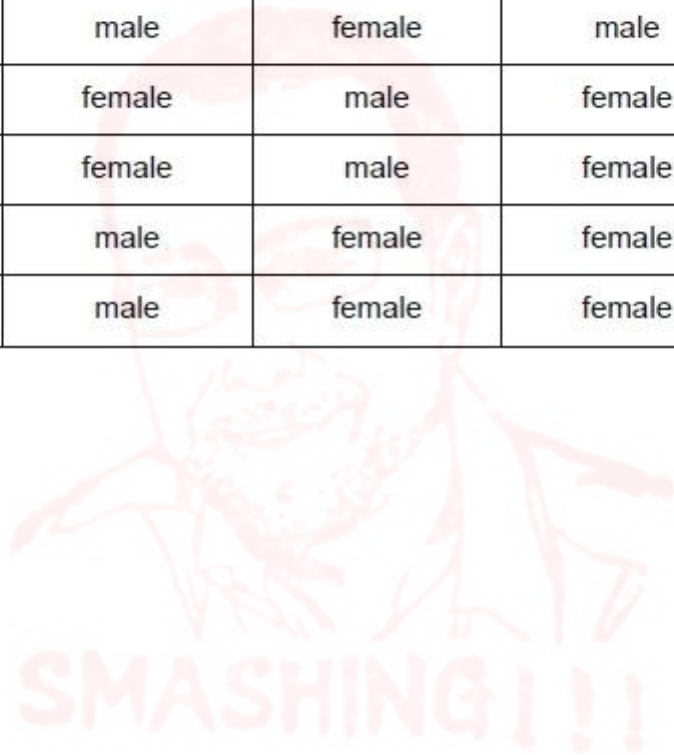
73 The sex of a species of fruit fly is determined by the number of X chromosomes relative to the number of non-sex chromosomes (A) in a cell. This is called the X:A ratio.

A fruit fly will be male if $X:A = 0.5:1$, and female if $X:A = 1:1$

The Y chromosome contains genes necessary for making sperm.

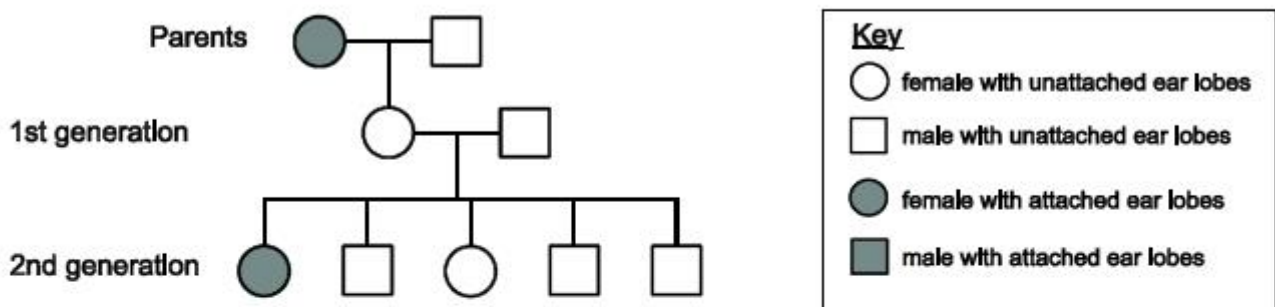
Which row of the table correctly shows the sex of the five fruit flies with different numbers of these chromosomes?

	XAA	XYAA	XXAA	XXYAA	XXYYAA
A	female	female	female	male	male
B	female	female	male	male	male
C	female	male	female	male	female
D	female	male	female	male	male
E	male	female	male	female	female
F	male	female	male	female	male
G	male	male	female	female	female
H	male	male	female	female	male



68 A person's ear lobes can be attached to the side of their head or unattached. The allele for attached ear lobes is recessive to the allele for unattached ear lobes.

The pedigree diagram below shows the ear lobe attachment in one family.



What is the maximum possible number of heterozygous individuals in this pedigree diagram?

- A 2
- B 3
- C 4
- D 5
- E 6
- F 7
- G 8
- H 9



65 The karyogram below is a photograph of the chromosomes taken from a single human cell.



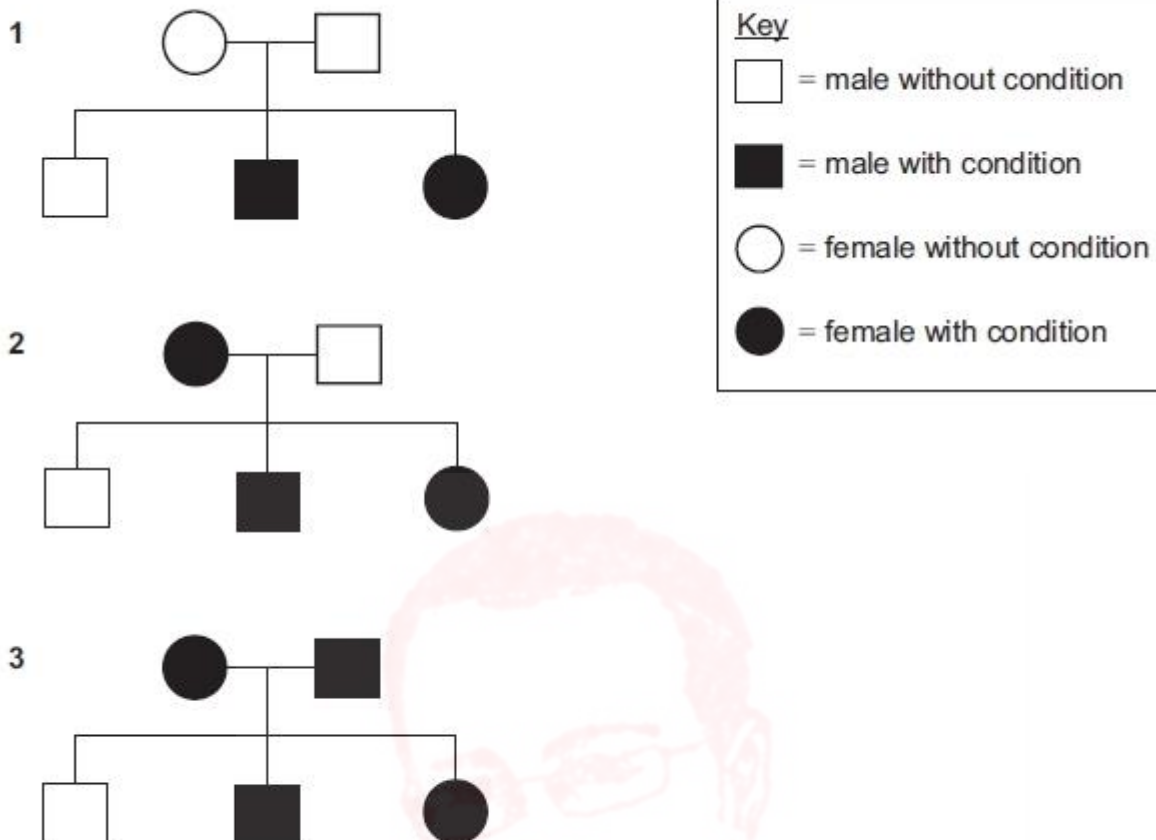
Using the karyogram, which of the following statements is/are correct?

- 1 The person is healthy with no visible mutations.
- 2 These chromosomes come from a male cell.
- 3 The cell used could have been a white blood cell.

- A none of them
- B 1 only
- C 2 only
- D 3 only
- E 1 and 2 only
- F 1 and 3 only
- G 2 and 3 only
- H 1, 2 and 3

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- 80** The three family trees show the inheritance of three different genetic conditions, each controlled by one gene with one dominant and one recessive allele.



In which of the family trees **must** the male parent be heterozygous?

(Assume that no new mutations occur and that the genes are not found on the X chromosome.)

- A** none of them
- B** 1 only
- C** 2 only
- D** 3 only
- E** 1 and 2 only
- F** 1 and 3 only
- G** 2 and 3 only
- H** 1, 2 and 3

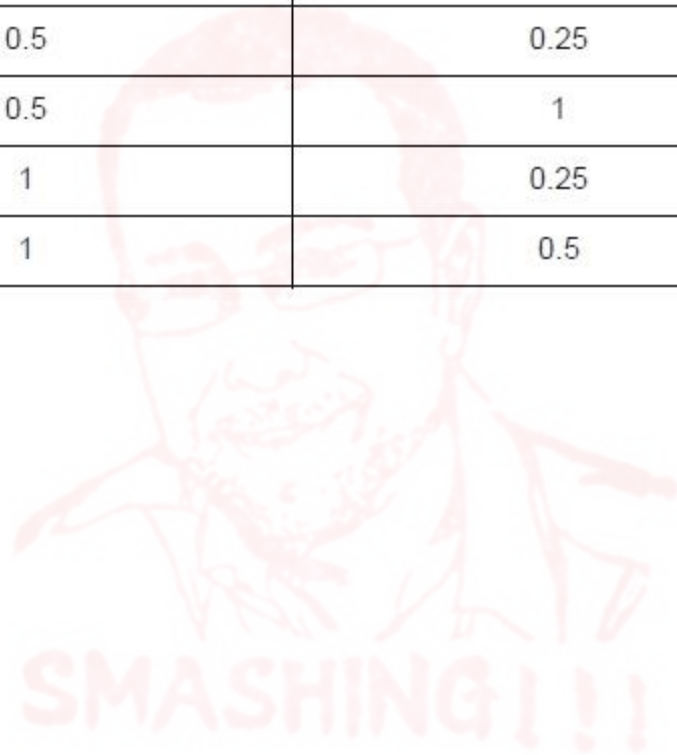
79 In rabbits, there are two alleles concerned with dark pigment in the fur:

- the dominant allele, B, for black colour
- the recessive allele, b, for brown colour

Two male black rabbits of unknown genotype each mated with a different female brown rabbit.

What is the expected proportion of brown offspring if both male rabbits are heterozygous, and what is the expected proportion of brown offspring if only one male rabbit is heterozygous?

	<i>expected proportion of brown offspring</i>	
	<i>if both male rabbits heterozygous</i>	<i>if only one male rabbit heterozygous</i>
A	0.25	0.5
B	0.25	1
C	0.5	0.25
D	0.5	1
E	1	0.25
F	1	0.5



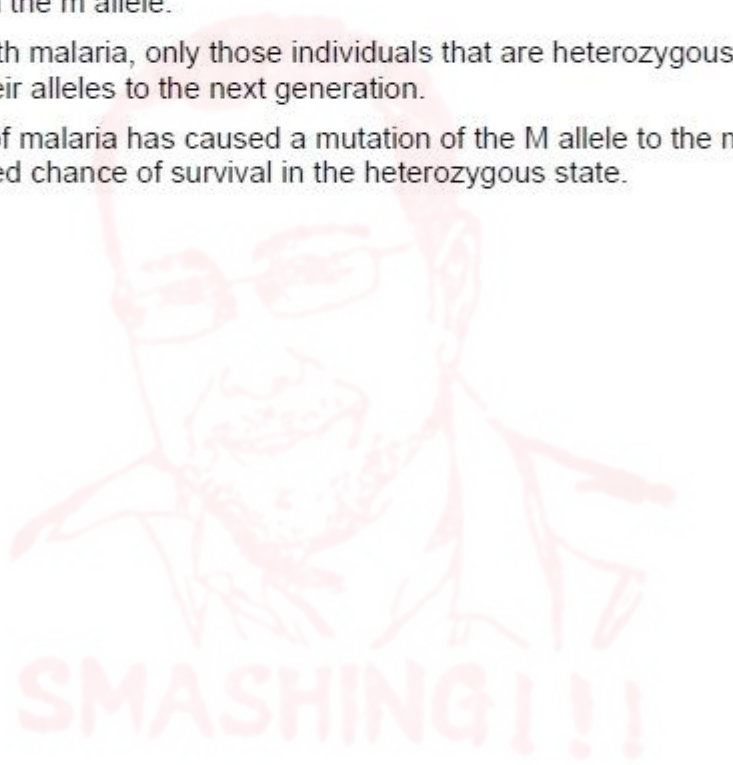
- 70** The table shows information about a human genetic condition called sickle cell anaemia and an infection called malaria. Both sickle cell anaemia and malaria can be fatal.

<i>genotype</i>	<i>phenotype</i>	<i>comment</i>
MM	does not show sickle cell anaemia	can be infected with malaria
Mm	does not show sickle cell anaemia	shows resistance to malaria
mm	shows sickle cell anaemia	shows more resistance to malaria than Mm

Which of the following statements is/are correct?

- 1** In areas without malaria, human populations are likely to have a low number of people with the m allele.
- 2** In areas with malaria, only those individuals that are heterozygous will be able to pass on their alleles to the next generation.
- 3** Presence of malaria has caused a mutation of the M allele to the m allele leading to an increased chance of survival in the heterozygous state.

- A** none of them
- B** 1 only
- C** 2 only
- D** 3 only
- E** 1 and 2 only
- F** 1 and 3 only
- G** 2 and 3 only
- H** 1, 2 and 3

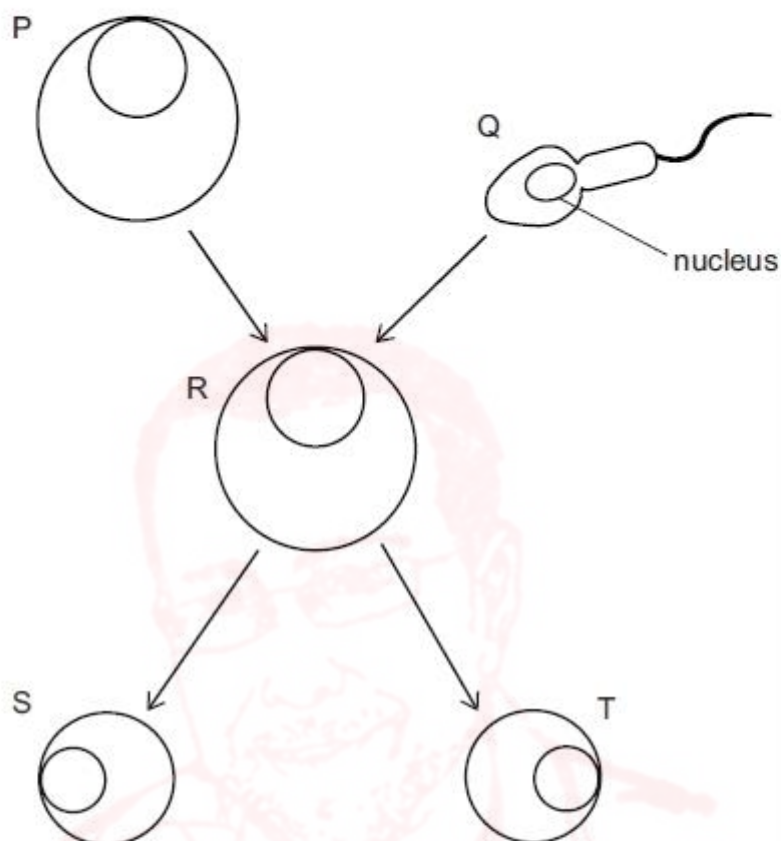


65 The diagram shows two human gametes, cell P and cell Q, fusing to form cell R.

Cell P carries an additional copy of one of its chromosomes so that it has one more chromosome than cell Q.

Cell R divides to form two cells S and T.

S and T grow into two separate individuals.



Using this information, which row shows the correct number of chromosomes in the nucleus of cell R and in the nucleus of cell T?

	cell R	cell T
A	23	24
B	24	47
C	24	48
D	46	46
E	47	24
F	47	47
G	92	47
H	93	93

61 Which of the following **could** lead to phenotypic variation between a father and his son?

- 1 time spent in sunlight
 - 2 their genomes
 - 3 their diets
-
- A none of them
 - B 1 only
 - C 2 only
 - D 3 only
 - E 1 and 2 only
 - F 1 and 3 only
 - G 2 and 3 only
 - H 1, 2 and 3

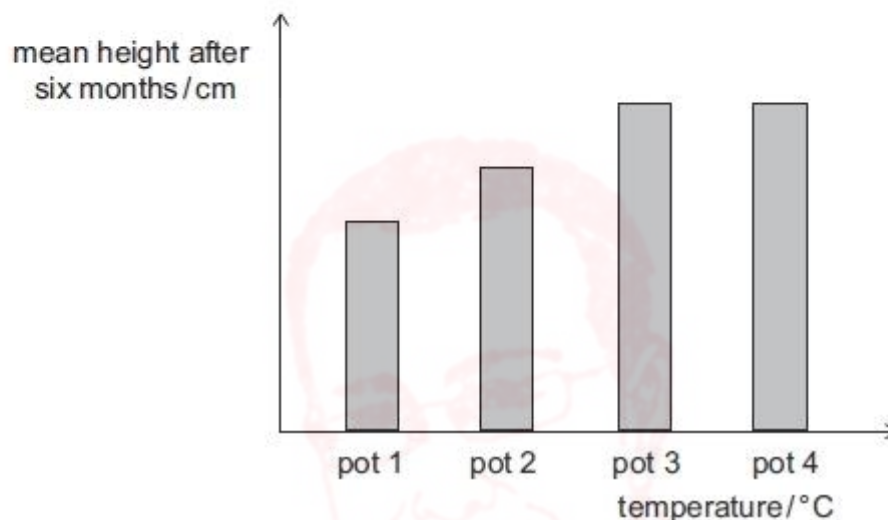


70 An investigation was carried out using clones of one plant.

Twenty plants of the same initial height were selected and divided into four equal groups. Each group was grown for six months and their environments were controlled as follows:

- kept at a different temperature to each other
- grown in a pot with an equal mass of soil with the same nutrients
- watered with an equal volume of water
- kept in the same light intensity

After six months, the height of the plants was measured. The mean height of the plants in each pot was calculated. The results are shown in the chart.



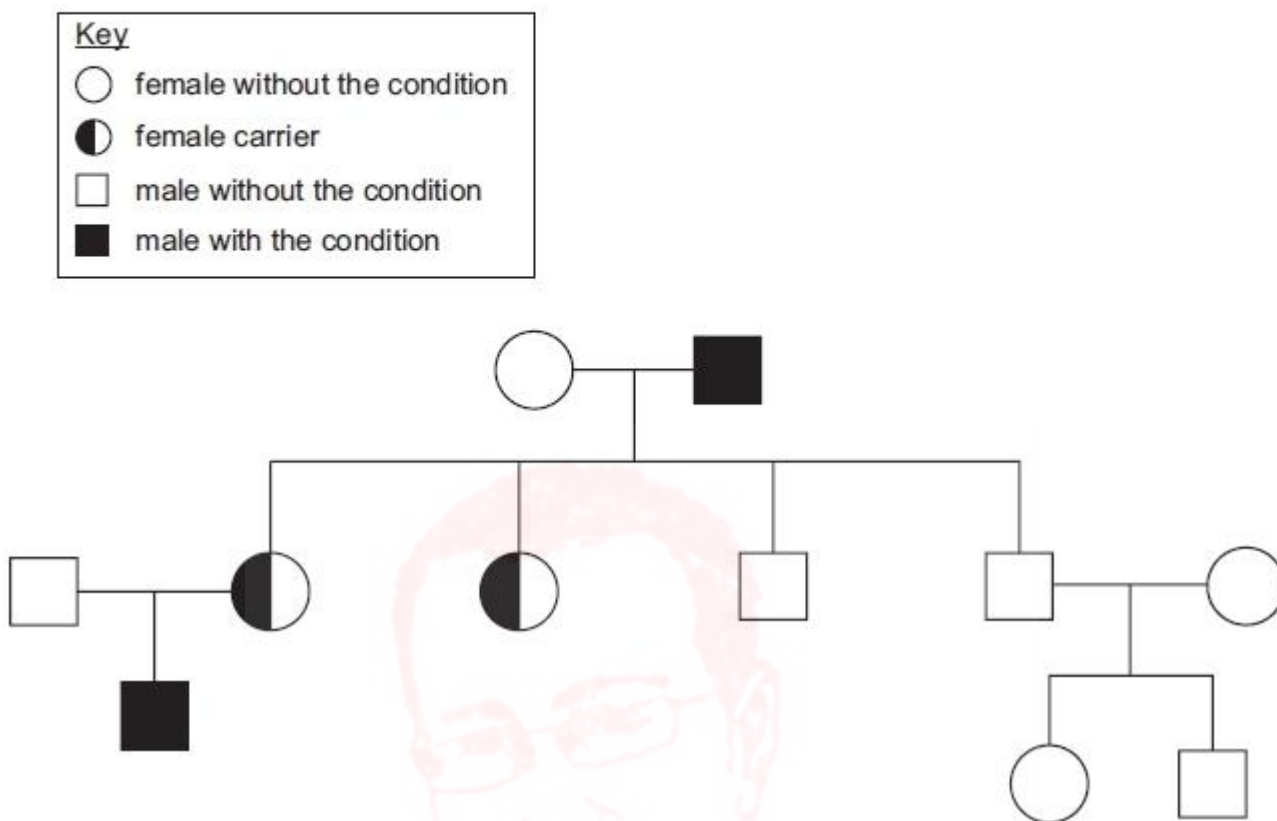
Which of the following statements could explain the results?

- 1 The difference in mean height between plants in pot 1 and plants in pot 2 could be due to the environment.
- 2 The mean height of plants in pot 4 equals that of plants in pot 3 because of another environmental factor in addition to temperature.
- 3 The mean height of plants in pot 3 equals that of plants in pot 4 because of the genotype of the plants.

- A none of them
- B 1 only
- C 2 only
- D 3 only
- E 1 and 2 only
- F 1 and 3 only
- G 2 and 3 only
- H 1, 2 and 3

- 68** A gene found on the X chromosome in humans has two alleles, dominant and recessive. Individuals who have only recessive alleles have a condition that affects their eyesight.

The inheritance of the condition in one family is shown in the family tree.



If one living skin cell from each member of this family were analysed, how many of the following alleles would be found?

	<i>number of copies of the recessive allele</i>	<i>number of copies of the dominant allele</i>
A	2	7
B	2	12
C	2	14
D	4	7
E	4	12
F	4	14
G	6	7
H	6	12

- 66** A child is affected by a dominant genetic condition. All of his cells have the same genotype. The allele associated with this condition is not present in either of his parents.

Which of the following statements could explain this?

- 1 A mutation occurred during meiosis in his father.
 - 2 A random mutation occurred in his DNA after he was born.
 - 3 Both of his grandmothers had the condition.
- A none of them
- B 1 only
- C 2 only
- D 3 only
- E 1 and 2 only
- F 1 and 3 only
- G 2 and 3 only
- H 1, 2 and 3



72 A diploid plant cell divides by mitosis.

After mitosis of this cell, a mutation occurs that changes the genotype of **one** of the daughter cells. This mutant daughter cell produces a non-functional enzyme instead of the functional enzyme produced by the other daughter cell. This mutation has no effect on the phenotype of the plant or the number or length of chromosomes in the plant cell.

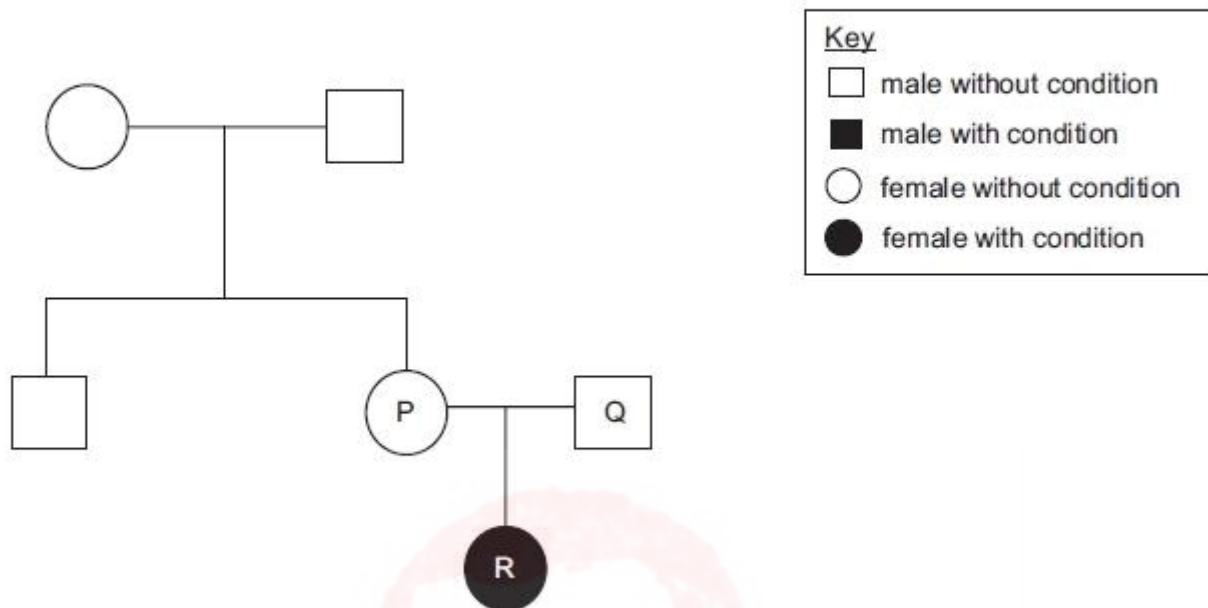
Which of the following statements describe the daughter cells after the mutation has occurred?

- 1 The chromosomes in the nucleus of each daughter cell will contain the same genes.
- 2 Both daughter cells will contain the same alleles for every gene.
- 3 The sequence of bases along each allele will be the same in each daughter cell.

- A none of them
- B 1 only
- C 2 only
- D 3 only
- E 1 and 2 only
- F 1 and 3 only
- G 2 and 3 only
- H 1, 2 and 3



- 65** The family tree shows a family affected by a dominant genetic condition. All people who carry the mutation show symptoms of the condition.

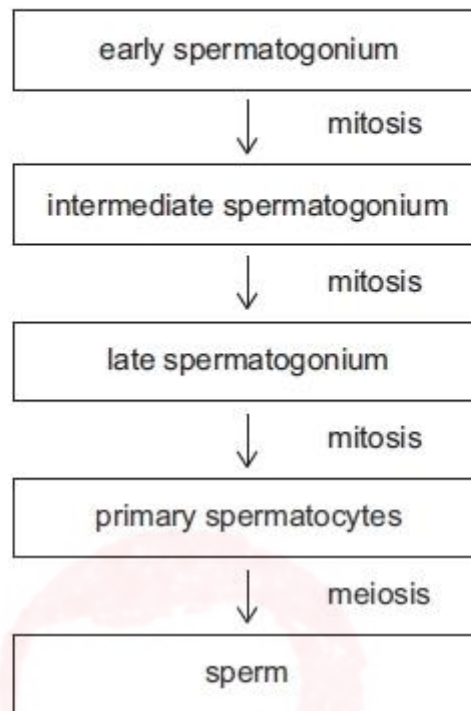


Which of the following statements could explain the presence of the dominant condition in female R?

- 1 The mutation occurs in P.
- 2 The mutation occurs in Q's father.
- 3 The mutation occurs in R.

- A none of them
- B 1 only
- C 2 only
- D 3 only
- E 1 and 2 only
- F 1 and 3 only
- G 2 and 3 only
- H 1, 2 and 3

- 60 The diagram shows four steps in the process of human sperm production. For each step only one complete division takes place.



Assuming no mutations and that all of the cells survive, what will be the maximum number of haploid cells originating from a single early spermatogonium?

- A 1
- B 2
- C 8
- D 16
- E 32
- F 64

59 A breeding experiment was carried out using rats.

A pair of rats has eight offspring per litter. The offspring breed freely amongst each other within the same generation. Each female is only allowed to have one litter of eight.

The expected ratio of male to female offspring in this breeding population is the same in rats as in humans, and is seen in every generation.

In the 4th generation of offspring, how many individuals would be expected to have the XY genotype?

- A 16
- B 32
- C 64
- D 128
- E 256
- F 512
- G 1024



- 56** Sickle cell anaemia is a recessive genetic condition that results in abnormally-shaped red blood cells due to the production of a faulty type of haemoglobin. Children born with sickle cell anaemia rarely live to adulthood without significant medical intervention. Carriers, who only have one copy of the sickle cell allele, have greater resistance to the disease malaria than people with two copies of the allele for normal functional haemoglobin.

Using this information, which of the following statements is/are correct?

- 1 People with sickle cell anaemia would have reduced anaerobic respiration in their muscle cells.
- 2 In areas with malaria the percentage of people surviving with sickle cell anaemia increases.
- 3 In parts of Africa where malaria is more common you would expect to find more people with a sickle cell allele.

- A none of them
- B 1 only
- C 2 only
- D 3 only
- E 1 and 2 only
- F 1 and 3 only
- G 2 and 3 only
- H 1, 2 and 3



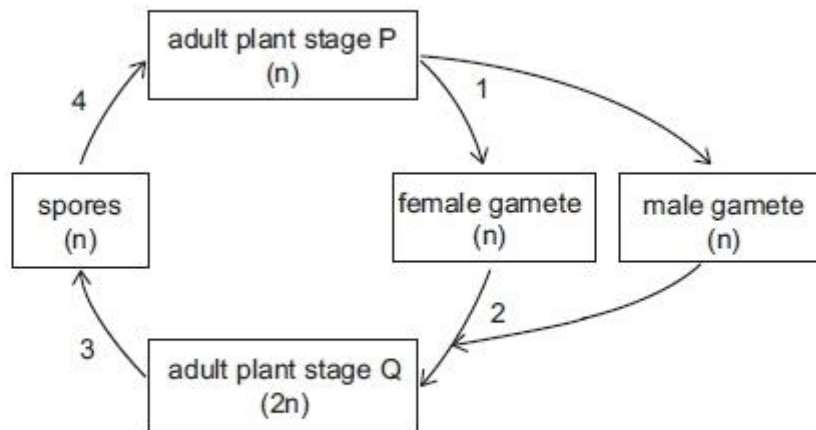
72 In a monohybrid cross, two heterozygotes were allowed to mate and the resulting offspring showed a 2 : 1 phenotypic ratio.

Which of the following statements could explain this ratio?

- 1 The number of offspring produced was small.
 - 2 The recessive condition was lethal prior to birth.
 - 3 Being homozygous dominant was lethal prior to birth.
- A none of them
- B 1 only
- C 2 only
- D 3 only
- E 1 and 2 only
- F 1 and 3 only
- G 2 and 3 only
- H 1, 2 and 3



66 The diagram shows the life cycle of a simple type of plant.



Key

n = haploid number of chromosomes

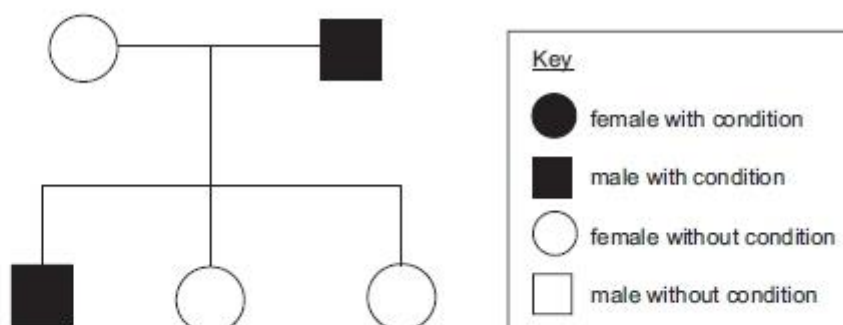
$2n$ = diploid number of chromosomes

At which two of the numbered stages does only mitosis occur?

- A 1 and 2 only
- B 1 and 3 only
- C 1 and 4 only
- D 2 and 3 only
- E 2 and 4 only
- F 3 and 4 only

64 An inherited condition is caused by a recessive allele.

The family tree shows the inheritance of this condition in one family.



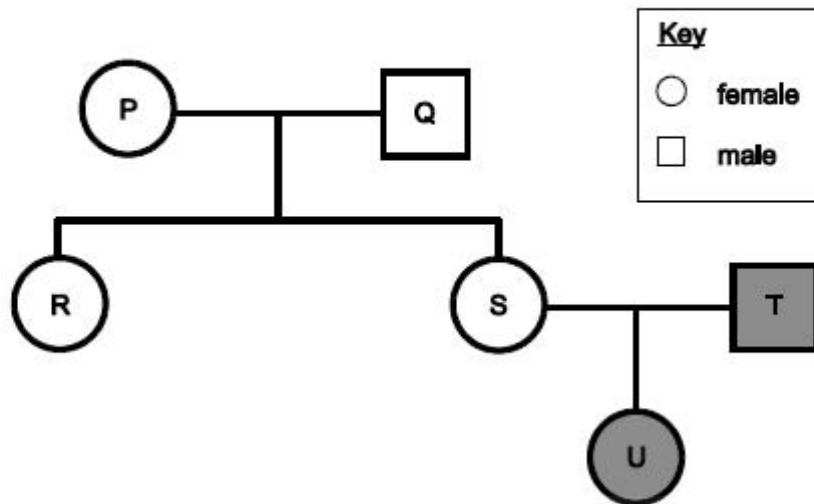
One of the daughters in this family tree has children with a man who does not have the condition.

For the two situations described in the table, which row shows the probability that their first child will be a girl who has the condition?

(Assume no new mutations.)

	<i>father is homozygous dominant</i>	<i>father is heterozygous</i>
A	0	0
B	0	0.125
C	0	0.25
D	0.5	0
E	0.5	0.125
F	0.5	0.25

71 The genetic condition represented by the shading is caused by the presence of at least one allele for the condition.



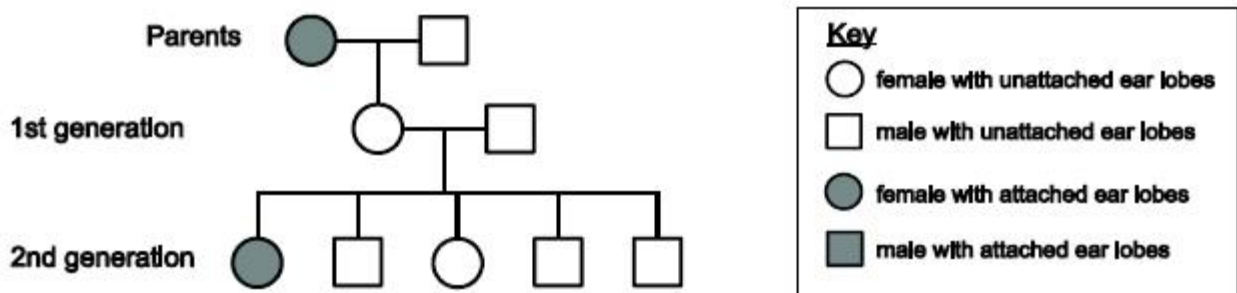
Which of the following are possible reasons why U has the condition?

- 1 The condition is dominant.
- 2 The sperm from T carried the allele for the condition.
- 3 A mutation is present in an egg of S.

- A 1 and 2 only
- B 1 and 3 only
- C 2 and 3 only
- D 1, 2 and 3
- E none of them

62 A person's ear lobes can be attached to the side of their head or unattached. The allele for attached ear lobes is recessive to the allele for unattached ear lobes.

The pedigree diagram below shows the ear lobe attachment in one family.



What is the maximum possible number of heterozygous individuals in this pedigree diagram?

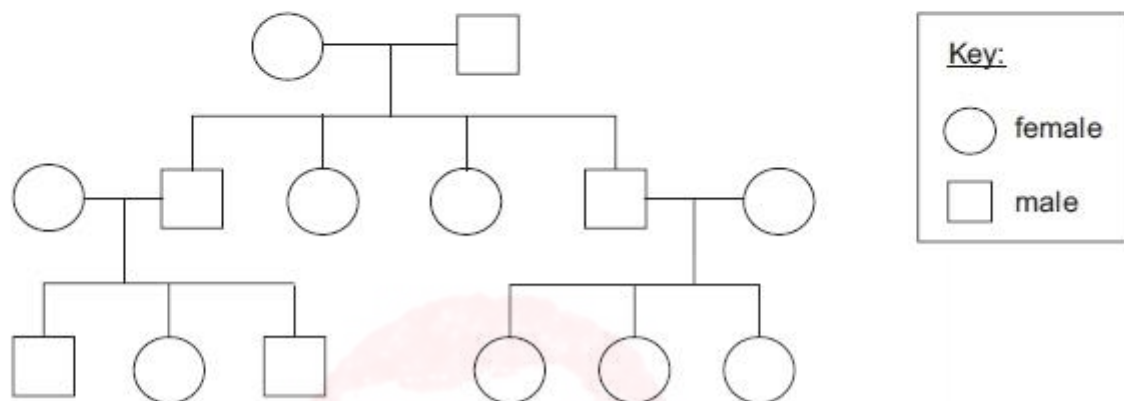
- A 2
- B 3
- C 4
- D 5
- E 6
- F 7
- G 8
- H 9



69 The sex of species Q is controlled by two chromosomes X and Y.

The sex of females of species Q is controlled by inheriting the same combination of sex chromosomes as healthy **male** humans. The sex of males in species Q is inherited in the same way as healthy **female** humans.

The family tree for one population of species Q is shown.



What is the ratio in its simplest form of males to females and the total number of Y chromosomes in this family tree?

	<i>ratio</i>	<i>total number of Y chromosomes</i>
A	1:0.5	9
B	1.8:1	9
C	5:9	5
D	5:9	9
E	9:5	9
F	9:5	19
G	1:2	19

67 A diploid cell from a type of fly that contains 8 chromosomes, divides to form sperm cells.

Which row is correct for the number of strands of DNA in each sperm cell and the number of sperm cells produced?

	<i>number of strands of DNA in each sperm cell</i>	<i>number of sperm cells produced</i>
A	4	2
B	4	4
C	8	2
D	8	4
E	16	2
F	16	4

65 Cystic fibrosis is a condition of the respiratory system caused by abnormal ion transport in the lungs. It is a recessive genetic condition.

A female carrier has a child with a male who is also a carrier. What are the probabilities of the child having the characteristics described in the table below?

	<i>probability that the child is a male with cystic fibrosis</i>	<i>probability that the child is a female who does not have cystic fibrosis but carries the recessive allele</i>
A	$\frac{1}{4}$	$\frac{1}{8}$
B	$\frac{1}{4}$	$\frac{1}{4}$
C	$\frac{1}{4}$	$\frac{1}{2}$
D	$\frac{1}{6}$	$\frac{1}{8}$
E	$\frac{1}{6}$	$\frac{1}{4}$
F	$\frac{1}{6}$	$\frac{1}{2}$
G	$\frac{1}{8}$	$\frac{1}{4}$
H	$\frac{1}{8}$	$\frac{1}{2}$

- 59 Albinism is a recessive genetic condition that results in the absence of the pigment melanin in the skin, hair and eyes. In a population of 580 000 people there were 29 albinos and 81 200 symptomless carriers. One living cheek cell was collected from every individual in the population.

What is the number of albinism alleles in these cells?

- A 0
- B 29
- C 58
- D 81 229
- E 81 258
- F 162 458

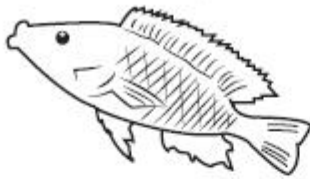
Which of the four statements below about natural selection are correct?

1. Competition occurs between individuals of the same species.
2. Competition occurs between individuals of different species.
3. Selection can lead to evolution.
4. Selection can lead to extinction.

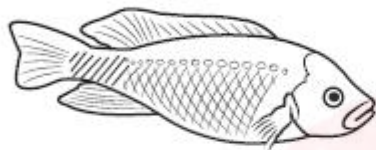
- ☐ 1 and 3 only
- ☐ 2 and 4 only
- ☐ 1, 2 and 4 only
- ☐ 1, 3 and 4 only
- ☐ 2, 3 and 4 only
- ☐ 1, 2, 3 and 4

- 68 Many different species of cichlid fish have evolved from a common ancestor. The drawing shows some of the species that have evolved in Lake Victoria in Africa.

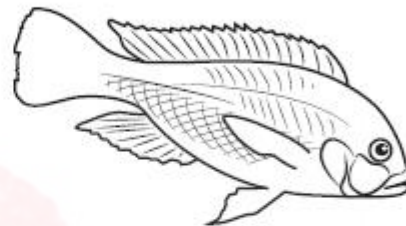
Haplochromis chilotes
(feeds on insects)



Haplochromis macrognathus
(feeds on other fish)



Astatotilapia elegans
(generalised bottom feeder)



Macropleuroodus bicolor
(feeds on snails and other molluscs)

Which of the following statements about evolution of the cichlid fish is/are correct?

- 1 Different food types being available caused mutations in the DNA of the ancestral population of fish.
- 2 Natural selection was possible because there were multiple alleles of the genes affecting the traits shown in the diagram.
- 3 Natural selection of individuals with phenotypes best suited to different parts of the environment took place.

- A none of them
- B 1 only
- C 2 only
- D 3 only
- E 1 and 2 only
- F 1 and 3 only
- G 2 and 3 only
- H 1, 2 and 3

61 A selection pressure is a biological or physical factor in an environment that may result in evolution.

Which of the following situations result in selection pressures on one or more organisms?

- 1 clearing rainforests to grow palm oil plantations
- 2 introduction of a predator to islands with seabird colonies
- 3 long-term use of antibiotics in hospital wards
- 4 using an insecticide to kill the mosquitoes that spread malaria

- A 1 and 2 only
- B 1 and 4 only
- C 2 and 3 only
- D 1, 2 and 3 only
- E 2, 3 and 4 only
- F 1, 2, 3 and 4

63 Which of the four statements below about natural selection are correct?

- 1 Competition occurs between individuals of the same species.
- 2 Competition occurs between individuals of different species.
- 3 Selection can lead to evolution.
- 4 Selection can lead to extinction.

- A 1 and 3 only
- B 2 and 4 only
- C 1, 2 and 4 only
- D 1, 3 and 4 only
- E 2, 3 and 4 only
- F 1, 2, 3 and 4

71 Bt pesticide is used by farmers to kill insect pests. However, widespread use has resulted in the evolution of resistance to this pesticide. A recessive allele causes resistance.

Scientists have suggested that in areas where the Bt pesticide is used, a small number of fields are left untreated. These untreated fields are known as *refugia*. This method has been shown to slow down evolution of resistance to the pesticide.

Which of the following statements explain why refugia could slow down the evolution of resistance to Bt pesticide?

- 1 When resistant insects breed with pesticide-sensitive insects that do not have the allele for resistance, the offspring produced will be sensitive to the pesticide.
- 2 When fewer insects are exposed to pesticide, fewer mutations occur that produce alleles for resistance.
- 3 The refugia help to maintain genetic variation in the population of insect pests.

- A none of them
- B 1 only
- C 2 only
- D 3 only
- E 1 and 2 only
- F 1 and 3 only
- G 2 and 3 only
- H 1, 2 and 3

57 Which of the four statements below about natural selection are correct?

- 1 Competition occurs between individuals of the same species.
- 2 Competition occurs between individuals of different species.
- 3 Selection can lead to evolution.
- 4 Selection can lead to extinction.

- A 1 and 3 only
- B 2 and 4 only
- C 1, 2 and 4 only
- D 1, 3 and 4 only
- E 2, 3 and 4 only
- F 1, 2, 3 and 4

- 55** Between 1954 and 1971 a mine in Northern Australia was releasing excess copper into the nearby Finnis River. Copper ions are poisonous and most of the types of fish living in the river died. The river still remains polluted with copper, but scientists have discovered one type of rainbow fish that is able to survive and live in the river.

A student wrote the following statements in order to explain this information.

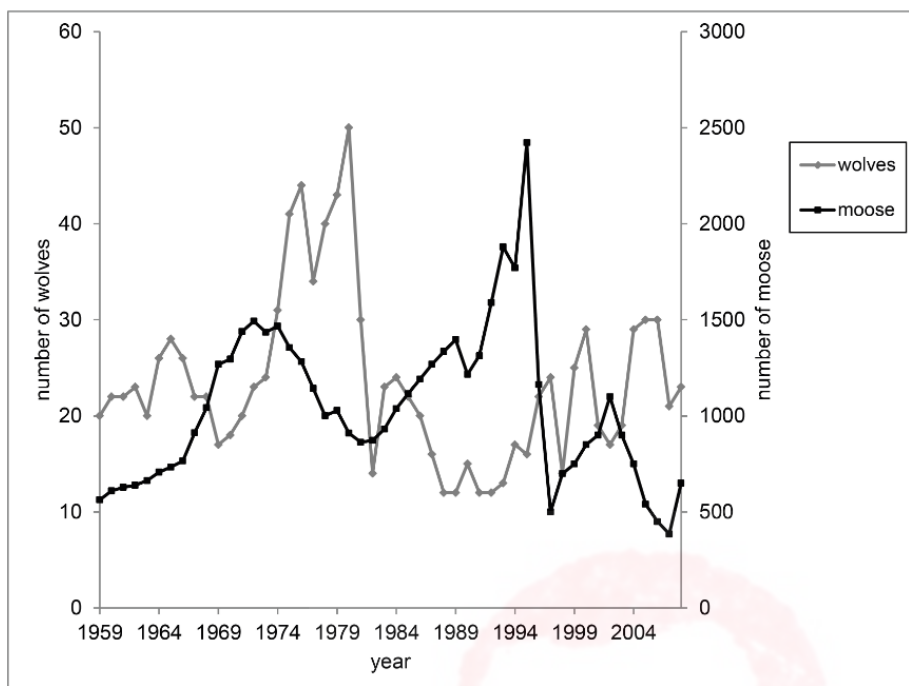
- 1 One type of rainbow fish did not die out in the river because this type was able to adapt to the changing environment.
- 2 None of the other types of fish showed any type of genetic variation.
- 3 The presence of copper ions acted as a selective pressure.

Which of the student's statements could be correct?

- A 1 only
- B 1 and 2 only
- C 1 and 3 only
- D 2 and 3 only
- E 1, 2 and 3



An isolated island in Canada has populations of moose and wolves. Moose are the main source of food for the wolves. The graph shows changes in the populations of the two species of animal from 1959 to 2008.



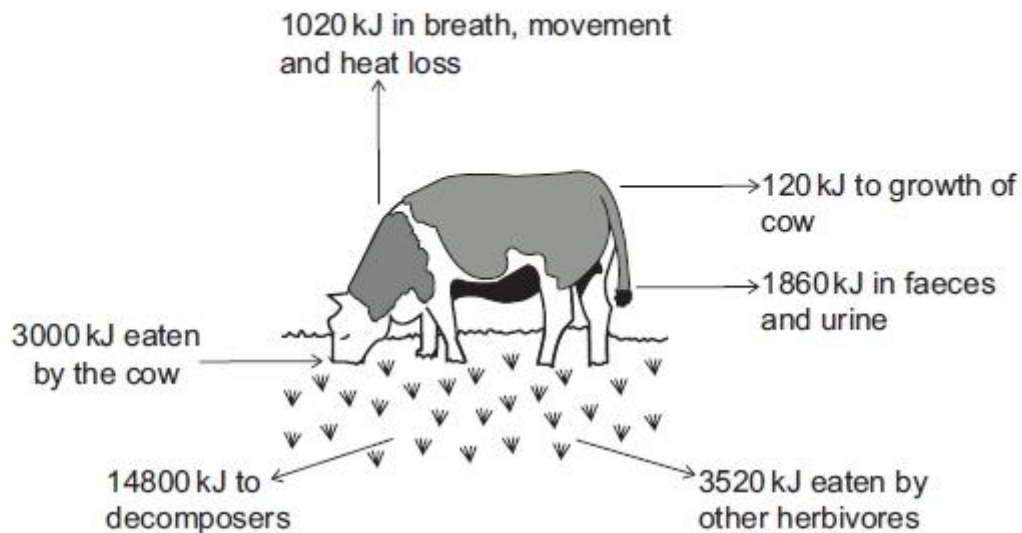
A student listed four trends in the populations of moose and wolves from 1959 to 2008.

1. Increases in wolf population are always after increases in moose population.
2. The wolf population is always lower than the moose population.
3. There were more wolves than moose in 1965.
4. When the wolf population is low there is an increase in the moose population.

Which of the student's statements are correct?

- ☐ 1 and 2 only
☐ 1 and 3 only
☐ 1 and 4 only
☐ 2 and 4 only
☐ 3 and 4 only

63 The diagram shows the flow of energy in a year's growth of grass from 1 m² of grassland.



Which of the following statements is/are correct?

- 1 62% of the energy consumed by the cow is lost in faeces and urine.
- 2 The diagram illustrates all the main processes of carbon uptake and release in the carbon cycle.
- 3 4% of the energy absorbed by the cells of the cow is used for growth.

- A none of them
- B 1 only
- C 2 only
- D 3 only
- E 1 and 2 only
- F 1 and 3 only
- G 2 and 3 only
- H 1, 2 and 3

- 61** Ambrosia beetles carry fungal spores from tree to tree. The beetles make holes in the branches of trees and create a network of tunnels in the wood. The fungus grows along the walls of the tunnels providing the only food source for the beetles. The fungus can penetrate xylem vessels and block them, which eventually kills the tree.

Which option correctly describes the relationship between these organisms?

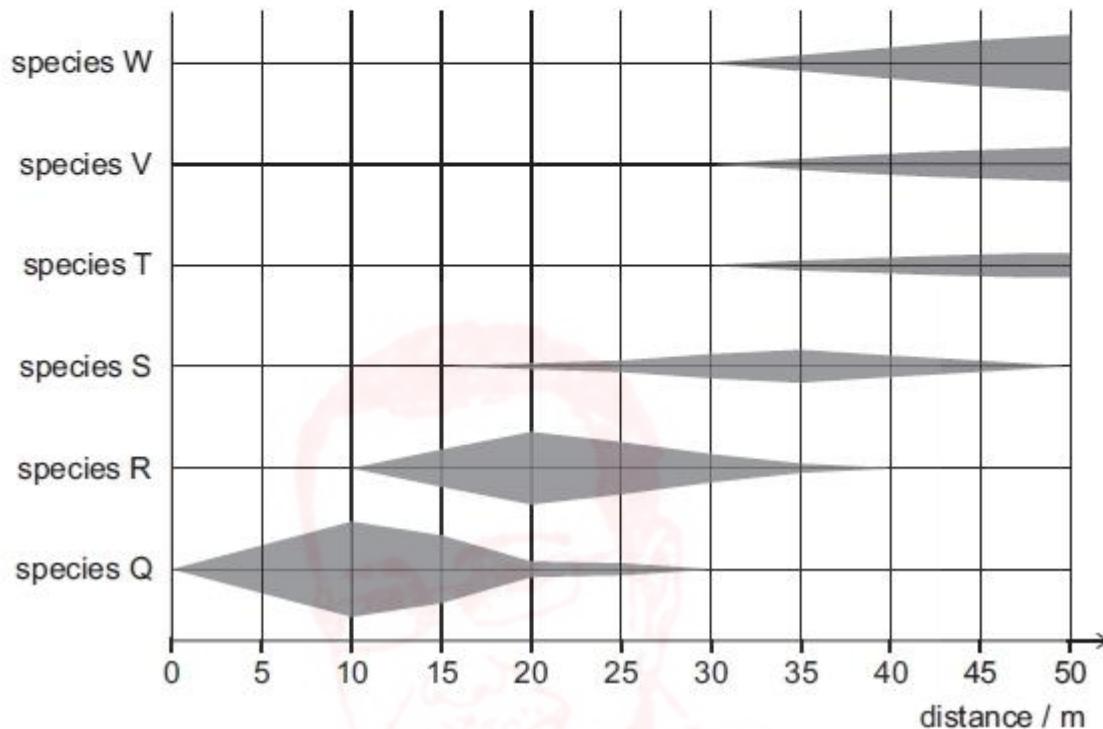
- A The beetle and the fungus have a mutualistic relationship.
- B The beetle and the tree have a mutualistic relationship.
- C The fungus is a parasite on the beetle.
- D The fungus is the primary producer that the beetle feeds on.
- E The tree is the primary producer that the beetle feeds on.



70 Some students collected data using a belt transect on a beach and recorded the results in a kite diagram.

The shading represents the number of individuals present at each point along the belt transect. The wider the shading in the vertical direction, the larger the number of individuals present. The vertical scale is the same for all species. The six species shown were the only ones present.

Data was recorded every 5 m along the belt transect.

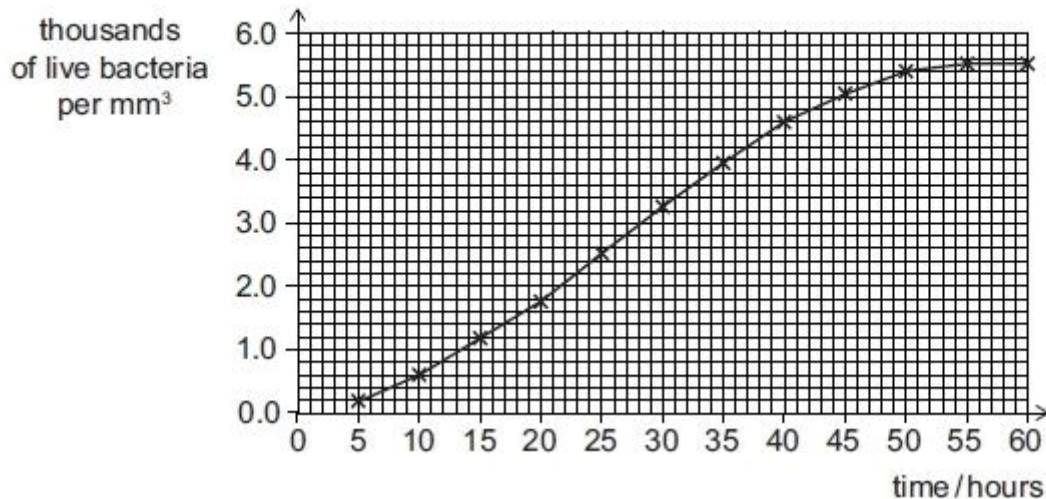


Which of the following statements is/are correct?

- 1 The sampling site with the highest number of different species is at 35 m.
- 2 The abundance of species T, V and W is the same.
- 3 At a distance of 5 m, species Q is the only species present.

- A none of them
- B 1 only
- C 2 only
- D 3 only
- E 1 and 2 only
- F 1 and 3 only
- G 2 and 3 only
- H 1, 2 and 3

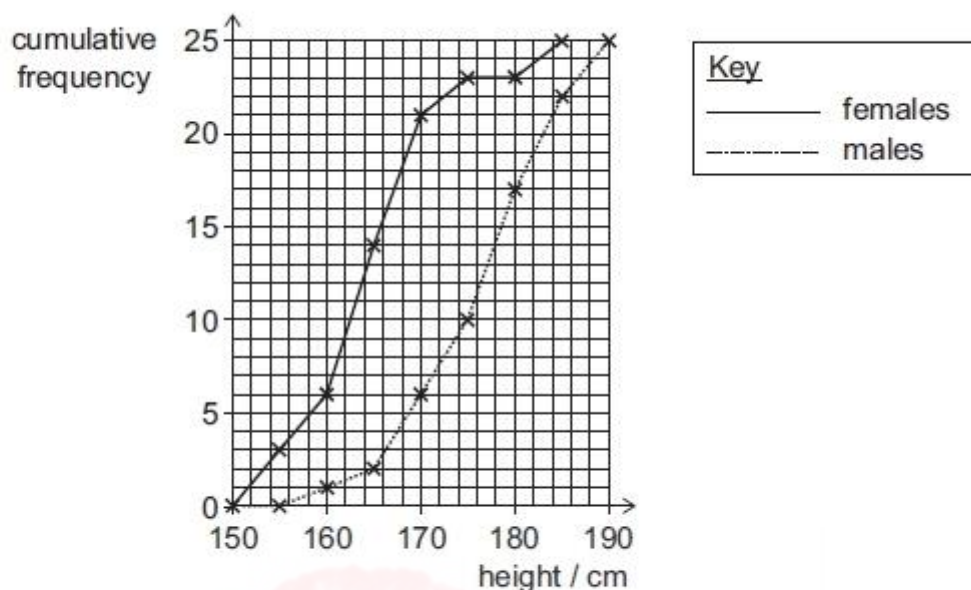
69 The graph shows the number of live bacteria growing in a nutrient broth at 30 °C over 60 hours.



Which statement is correct?

- A If there were no limiting factors, the number of live bacteria in the population would be directly proportional to time.
- B At 40 hours, there are on average 4.6 live bacteria per mm³.
- C At 60 hours, the number of bacteria dying is greater than the number being produced.
- D Some of the live bacteria in the population at 60 hours could be genetically different to the bacteria in the population at 5 hours.
- E There is no limiting factor affecting the population of live bacteria over the 60 hour period.

65 The graph shows the cumulative frequency for the heights of a group of 15-year-old students.



Which of the following statements is/are correct?

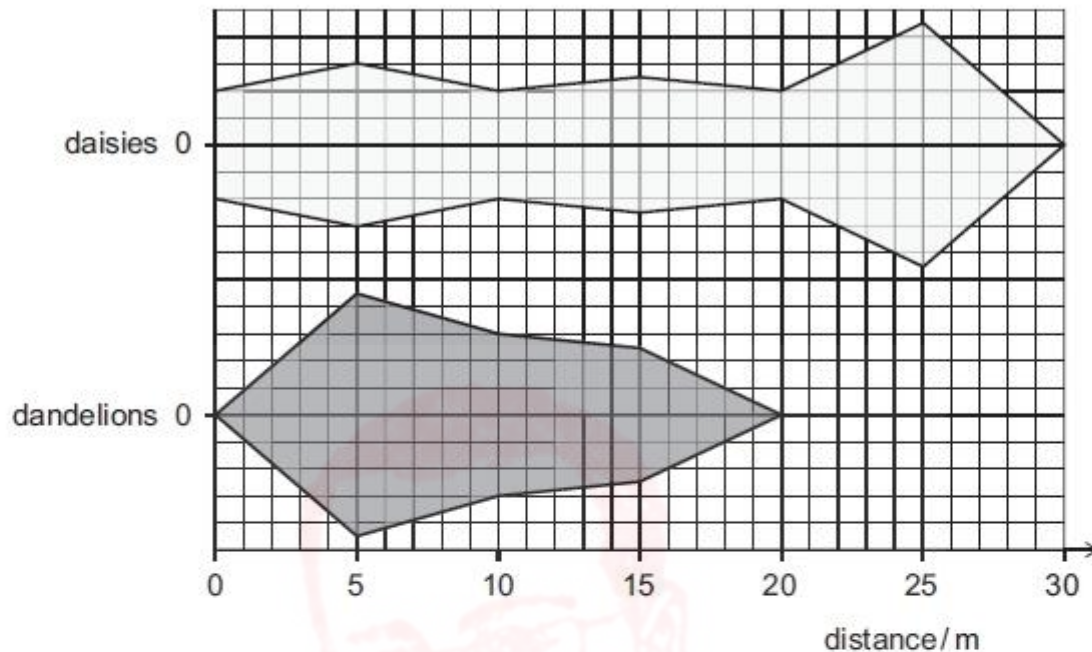
- 1 The difference between the mean heights of male and female students can be found by reading the difference in heights at a cumulative frequency of 12.5.
- 2 The difference in height between different males is explained by environmental factors alone.
- 3 The difference in the cumulative frequency graphs for males and females could be explained by a gene on the Y chromosome.

- A none of them
- B 1 only
- C 2 only
- D 3 only
- E 1 and 2 only
- F 1 and 3 only
- G 2 and 3 only
- H 1, 2 and 3

80 The kite diagram shows the distribution of dandelions and daisies along a transect in a field.

A quadrat with sides of 0.5m was used to collect the data.

Each square on the vertical axis represents 1 plant. For example, in the quadrat centred at 5 m there were 6 daisies.

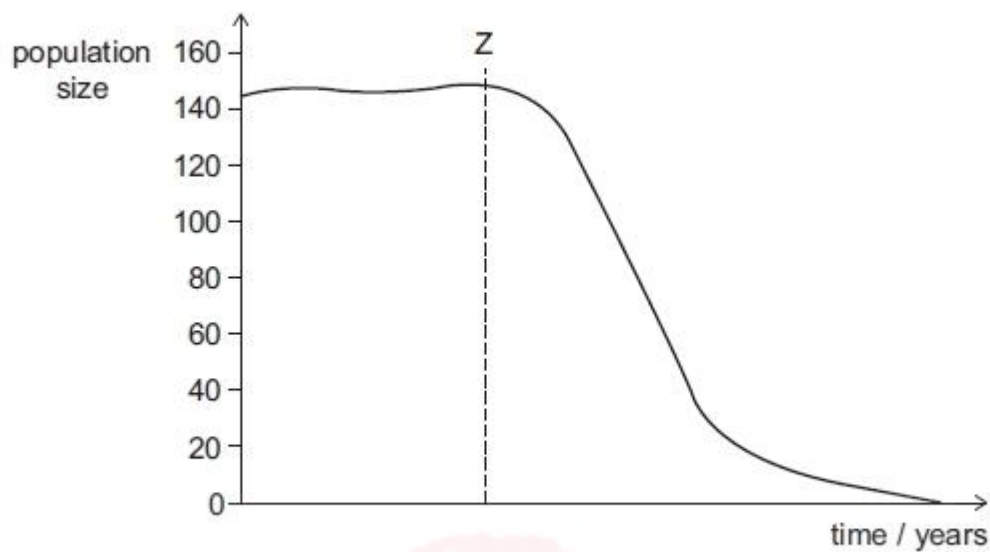


Which of the following statements about the data is/are correct?

- 1 Across the transect, the number of dandelions is proportional to the number of daisies.
- 2 Repeating the experiment along a different transect would result in an identical pattern.
- 3 The density of dandelions at 5 m is 36 plants per square metre.

- A none of them
- B 1 only
- C 2 only
- D 3 only
- E 1 and 2 only
- F 1 and 3 only
- G 2 and 3 only
- H 1, 2 and 3

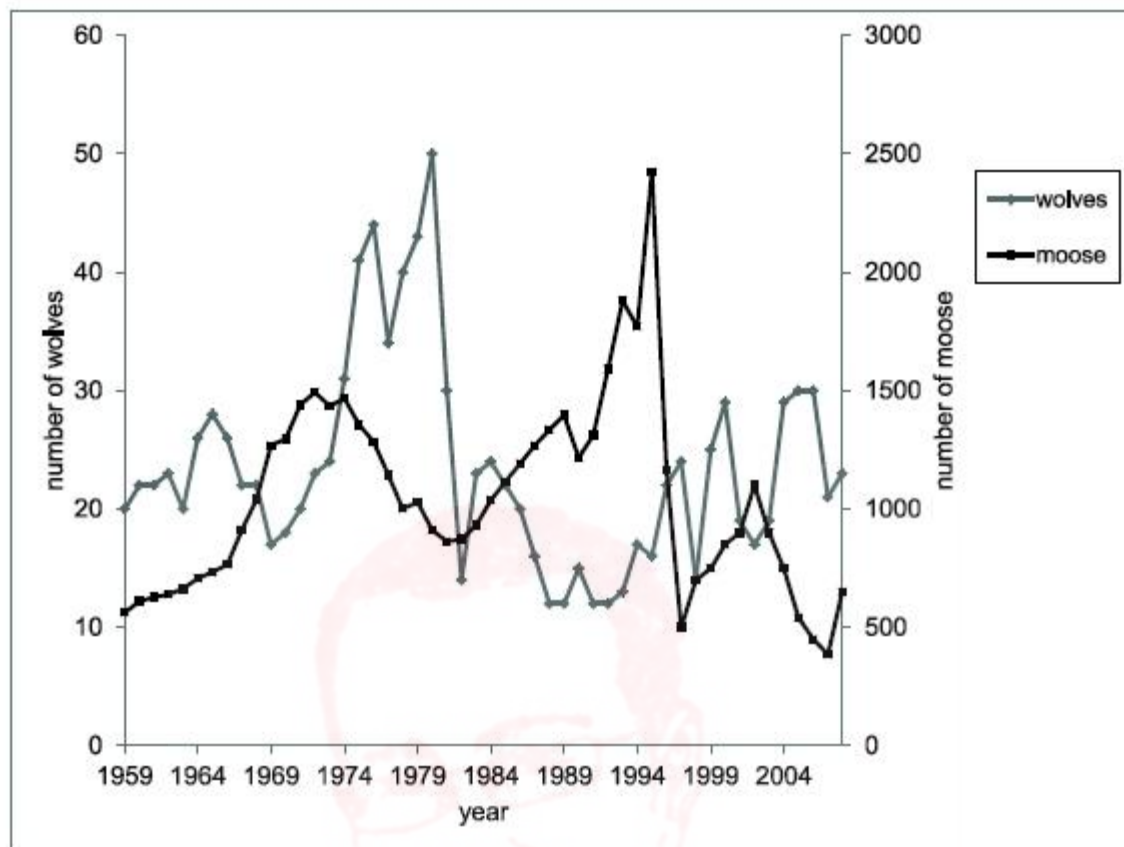
- 66** The graph shows changes in population size (number of individuals) of a species of tortoise over the last century. These tortoises are only found on one small island in the Galapagos.



Which of the following could account for the change in population shown after time Z on the graph?

- 1 reduced rainfall
 - 2 reduced availability of resources
 - 3 failure to adapt to competition from an introduced species
- A none of them
- B 1 only
- C 2 only
- D 3 only
- E 1 and 2 only
- F 1 and 3 only
- G 2 and 3 only
- H 1, 2 and 3

- 72** An isolated island in Canada has populations of moose and wolves. Moose are the main source of food for the wolves. The graph shows changes in the populations of the two species of animal from 1959 to 2008.



A student listed four trends in the populations of moose and wolves from 1959 to 2008.

- 1 Increases in wolf population are always after increases in moose population.
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- 3 There were more wolves than moose in 1965.
- 4 When the wolf population is low there is an increase in the moose population.

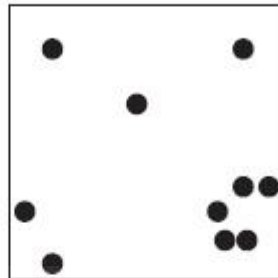
Which of the student's statements are correct?

- A 1 and 2 only
- B 1 and 3 only
- C 1 and 4 only
- D 2 and 4 only
- E 3 and 4 only

74 The abundance of a plant species in a habitat can be measured in different ways:

- the density (the number of that plant species per m^2)
- the frequency (the number of quadrats in which the plant species occurs)

The abundance of a plant species in a 100 m^2 area of grassland was measured. The diagram below represents this area of grassland. Each black circle represents one individual of the plant species in this area of grassland.



Two different size quadrats were used to sample the area:

- large quadrat ($50 \text{ cm} \times 50 \text{ cm}$)
- small quadrat ($10 \text{ cm} \times 10 \text{ cm}$)

The area is sampled randomly, first using 10 large quadrats and then a second time using 10 small quadrats.

Which of the following statements is/are correct?

- 1 The overall density in the grassland calculated from sampling with either size quadrat will always be the same.
- 2 The overall density in the grassland calculated from sampling will always be 1 plant per m^2 .
- 3 The frequency obtained using the small quadrat will always be lower than that obtained with the large quadrat.

- A none of them
- B 1 only
- C 2 only
- D 3 only
- E 1 and 2 only
- F 2 and 3 only
- G 1 and 3 only
- H 1, 2 and 3

69 Which of the following could be a result of the addition of a large amount of organic material into a slow flowing river?

- 1** A decrease in biodiversity in the river.
- 2** A reduction in the oxygen concentration gradient between the air and the water.
- 3** An increase in the size of at least one aquatic population.

- A** none of them
- B** 1 only
- C** 2 only
- D** 3 only
- E** 1 and 2 only
- F** 1 and 3 only
- G** 2 and 3 only
- H** 1, 2 and 3

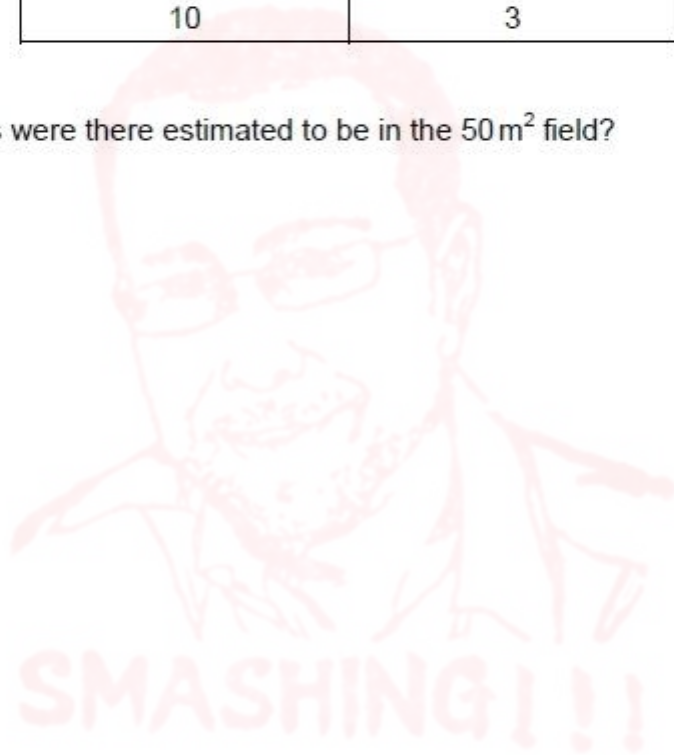


- 59 An ecologist used a 50 cm × 50 cm square quadrat to estimate the number of meadow buttercups present in a field with an area of 50 m². The quadrat was distributed randomly on ten occasions in the field and the number of buttercups counted in each quadrat.

<i>quadrat</i>	<i>number of buttercups</i>
1	3
2	10
3	0
4	4
5	21
6	19
7	6
8	11
9	15
10	3

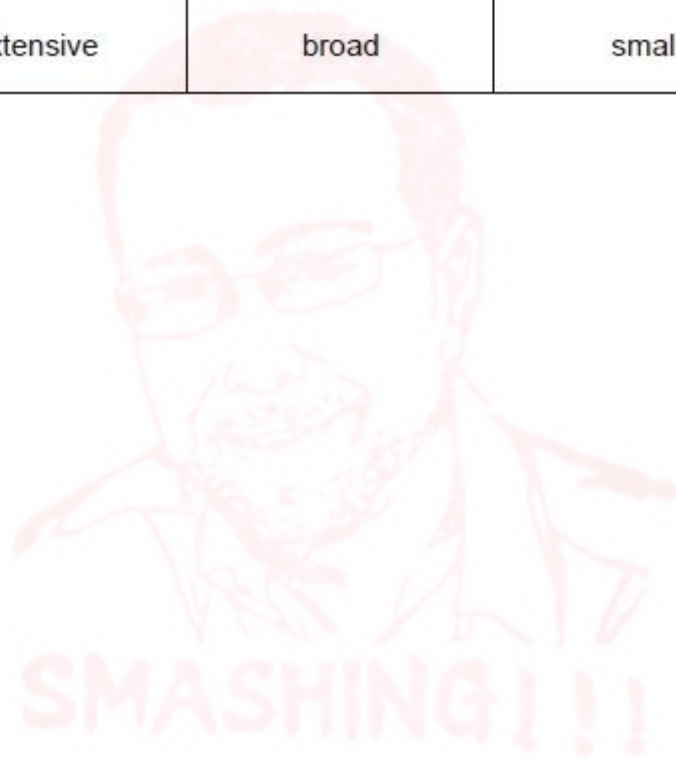
How many buttercups were there estimated to be in the 50 m² field?

- A 368
- B 460
- C 920
- D 1840
- E 4600
- F 18400
- G 45000



58 Using the information in the table, which animal (A-F) is most at risk of extinction?

<i>animal</i>	<i>geographic range</i>	<i>habitat tolerance</i>	<i>population size</i>
A	restricted	broad	large
B	extensive	broad	large
C	restricted	narrow	small
D	extensive	narrow	small
E	restricted	broad	small
F	extensive	broad	small



58 A student investigated the tadpole population in a large pond.

A net with a rectangular opening measuring $0.1 \text{ m} \times 0.2 \text{ m}$ was swept through the water for a fixed distance of 1 m. This was repeated 10 times.

All the sweeps were made at the edge of the pond as the student had no waders or boat.

The number of tadpoles in each sweep was recorded in the table.

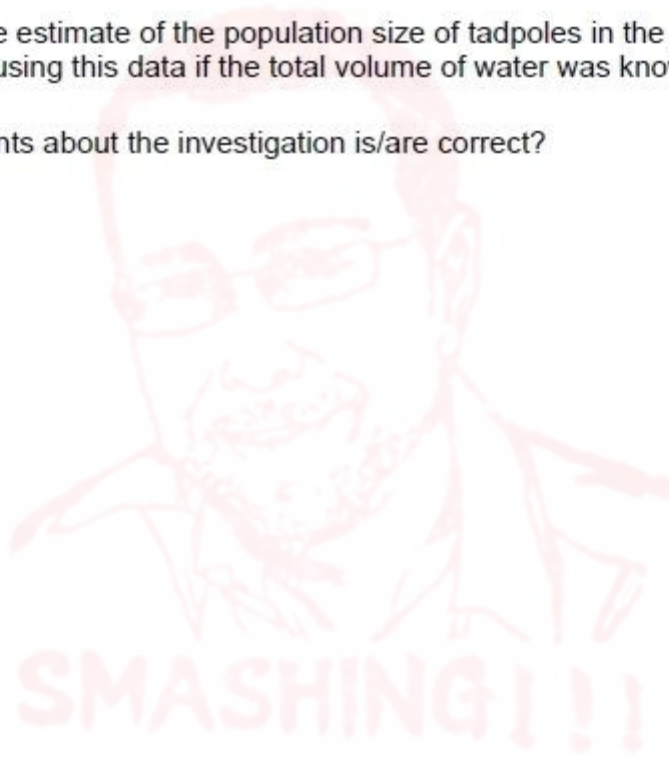
<i>sweep number</i>	1	2	3	4	5	6	7	8	9	10
<i>number of tadpoles</i>	20	12	32	0	4	8	4	8	12	20

The student made the following statements.

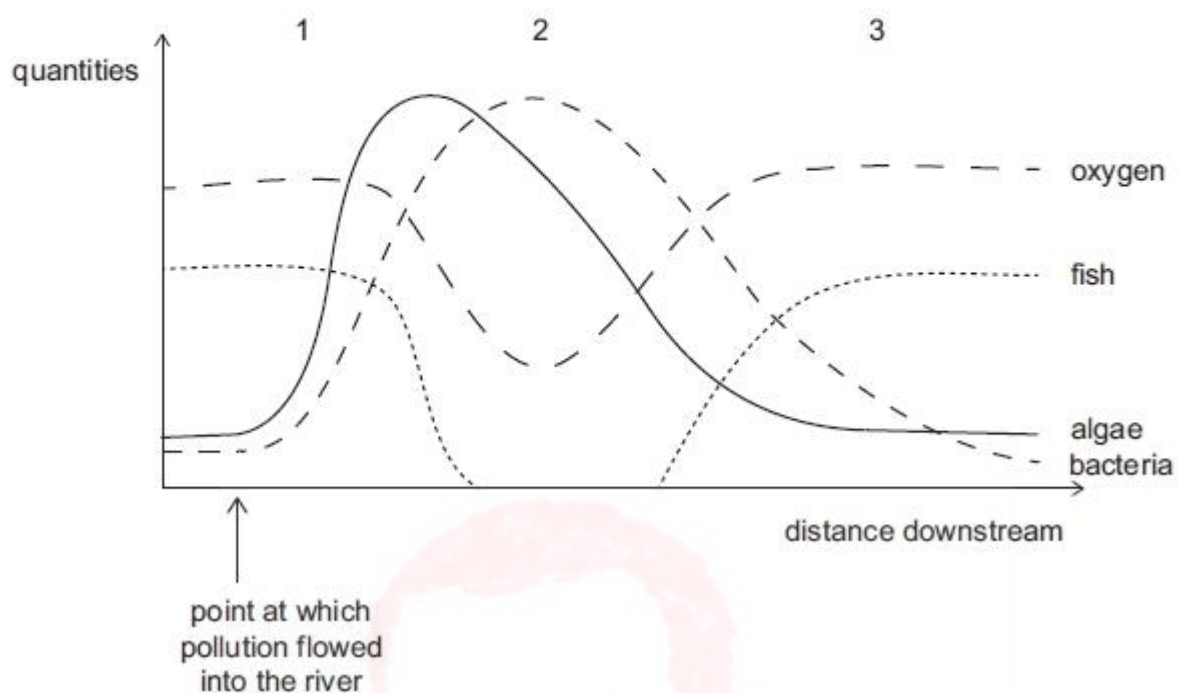
- 1 Each sweep sampled 0.02 m^3 of water.
- 2 The frequency of occurrence of the tadpoles was 90%.
- 3 An accurate estimate of the population size of tadpoles in the pond could be calculated using this data if the total volume of water was known.

Which of the statements about the investigation is/are correct?

- A none of them
- B 1 only
- C 2 only
- D 3 only
- E 1 and 2 only
- F 1 and 3 only
- G 2 and 3 only
- H 1, 2 and 3



- 55** The graph shows how four variables change with the distance down a river, after a source of pollution flowed in.



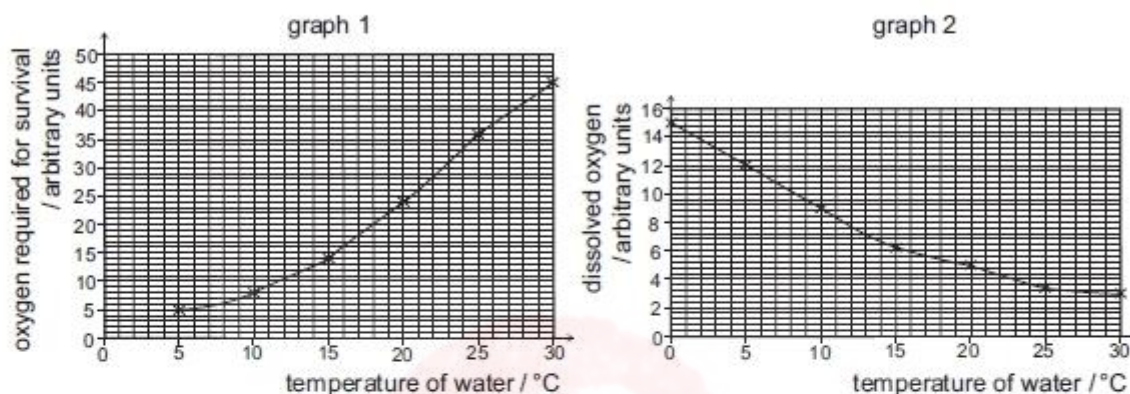
Which indicator species could be expected to be found in large numbers at 1, 2 and 3?

	1	2	3
A	bloodworm	bloodworm	bloodworm
B	bloodworm	bloodworm	stonefly
C	bloodworm	stonefly	bloodworm
D	bloodworm	stonefly	stonefly
E	stonefly	bloodworm	bloodworm
F	stonefly	bloodworm	stonefly
G	stonefly	stonefly	bloodworm
H	stonefly	stonefly	stonefly

- 71 A power station released warm water into a river. This is an example of water pollution because the temperature of the river water was increased.

A student was interested in the effects of the temperature increase on a pollution indicator species.

The student studied two graphs. Graph 1 showed the oxygen required by the pollution indicator species for survival and graph 2 showed the effect of temperature on the oxygen dissolved in the water.



The student wrote the following statements:

- 1 As the oxygen required by the pollution indicator species for survival increases, the water temperature rises.
- 2 There is less dissolved oxygen available to the pollution indicator species as the water temperature rises.
- 3 The pollution indicator species will survive better in water at 30 °C than at 5 °C because it has a greater oxygen uptake at 30 °C.

Which of the student's conclusions could be correct using only the information provided?

- A none of them
- B 1 only
- C 2 only
- D 3 only
- E 1 and 2 only
- F 1 and 3 only
- G 2 and 3 only
- H 1, 2 and 3

61 A desert food chain is shown below.

cactus → rat → rattlesnake → hawk

Assume that 10% of the energy from each stage in the food chain is passed on.

If 150 000 units of energy are contained in the producer, how much energy will be lost in the transfer between the primary and secondary consumers?

- A 1500
- B 13500
- C 15000
- D 135000
- E 148500

59 Which of the following will **always** lead to an increase in the size of a population?

- 1 removal of intraspecific competitors
- 2 supplying more of the nutrient that is at the lowest concentration
- 3 change in the organism's rate of reproduction

- A none of them
- B 1 only
- C 2 only
- D 3 only
- E 1 and 2 only
- F 1 and 3 only
- G 2 and 3 only
- H 1, 2 and 3

- 57 Ten randomly placed quadrats were used to estimate the frequency of occurrence of three plant species in a field.

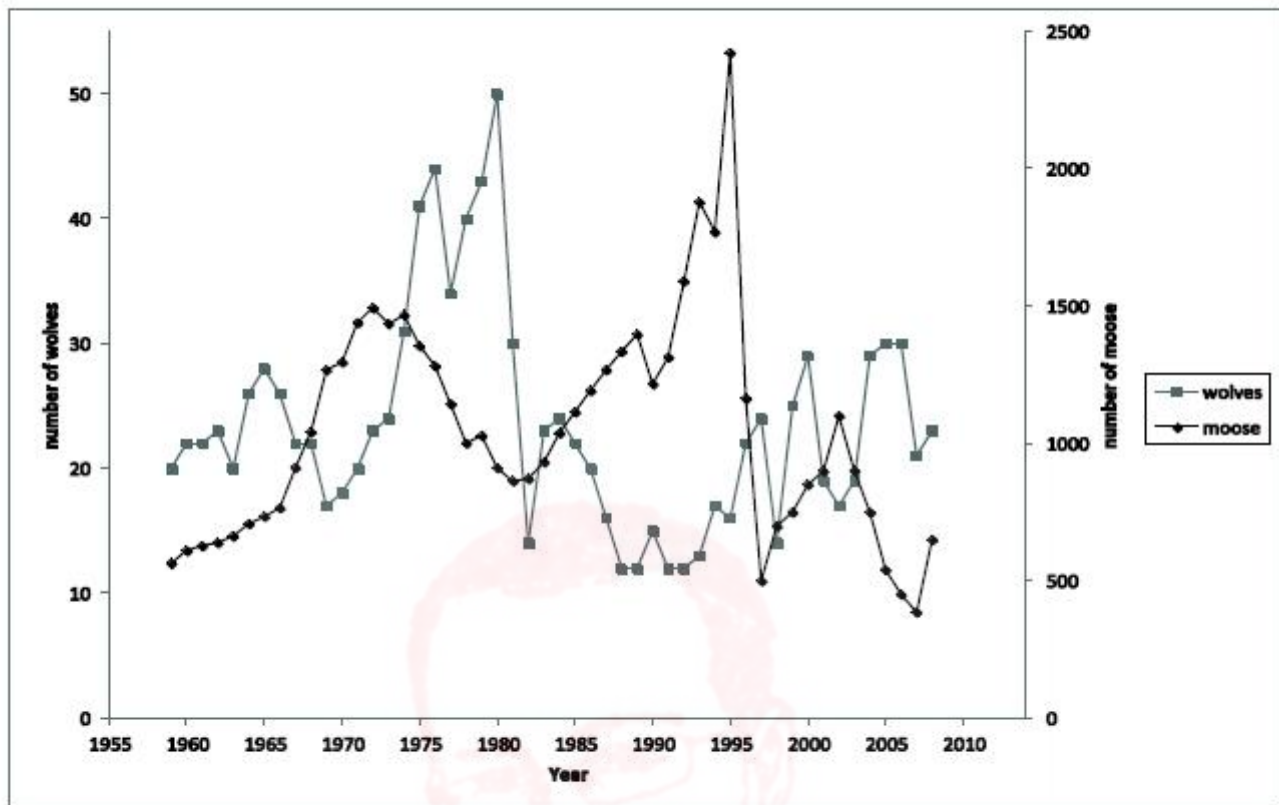
quadrat number	number of individuals of		
	species X	species Y	species Z
1	4	1	5
2	11	0	12
3	3	5	13
4	0	0	9
5	2	9	4
6	1	8	2
7	7	2	6
8	14	24	0
9	6	0	2
10	7	3	0

What was the correct lowest frequency of occurrence calculated from X or Y or Z?

- A 0
- B 0.2
- C 0.7
- D 1.0
- E 1.4
- F 5.2
- G 52.0



65 An isolated island in Canada has populations of moose and wolves. Moose are the main source of food for the wolves. The graph shows changes in the populations of the two species of animal from 1959 to 2008.



A student listed four trends in the populations of moose and wolves from 1959 to 2008.

- 1 Increases in wolf population are always after increases in moose population.
- 2 The wolf population is always lower than the moose population.
- 3 There were more wolves than moose in 1965.
- 4 When the wolf population is low there is an increase in the moose population.

Which of the student's statements are correct?

- A 1 and 2 only
- B 1 and 3 only
- C 1 and 4 only
- D 2 and 4 only
- E 3 and 4 only

61 A student studied an area of grassland by randomly distributing 25 equal-sized quadrats.

The student counted the numbers of daisies, dandelions, plantains and buttercups in each quadrat.

quadrat number	number of			
	daisies	dandelions	plantains	buttercups
1	2	2	0	0
2	4	0	0	0
3	4	0	0	1
4	2	0	0	1
5	1	0	1	1
6	3	0	0	0
7	0	2	0	0
8	0	1	0	2
9	0	0	1	2
10	0	0	2	1
11	2	0	0	1
12	0	3	0	0
13	0	0	0	2
14	0	1	0	0
15	0	0	1	1
16	2	2	0	0
17	0	2	0	0
18	0	0	0	0
19	0	0	3	0
20	0	3	1	0
21	3	0	0	1
22	2	2	0	0
23	0	5	0	0
24	0	1	1	0
25	0	1	2	0

The student then calculated the frequency of occurrence for each type of plant.

Which frequency of occurrence is correct for the daisy species?

- A 0.25
- B 0.33
- C 0.40
- D 3.00
- E 4.00

66 Organisms interact with each other in many different ways, for example:

- 1 a tapeworm absorbing nutrients from a sheep intestine
- 2 a bacterial cell breaking down undigested food in a human gut
- 3 a leopard and a lion hunting an antelope
- 4 male deer fighting with each other to gain a mate
- 5 oak trees growing close to each other in a wood

Which of the statements is/are an example of intraspecific competition?

- A 1 only
- B 2 only
- C 4 only
- D 2 and 3 only
- E 4 and 5 only
- F 1, 2 and 5 only
- G 1, 3 and 4 only

Topic 19 Q# 211/ Cambridge/2024/ESAT/ Biology/ Q# 22 /www.SmashingScience.org/

Which of the statements about the genetic modification of a bacterium to produce human insulin are correct?

1. Human insulin DNA is cut out using an enzyme.
2. This DNA is inserted into the nucleus of a bacterium.
3. The modified bacterium is cultured.
4. The bacterial cells are injected into humans with diabetes.

- ☐ 1 and 2 only
- ☐ 1 and 3 only
- ☐ 2 and 4 only
- ☐ 3 and 4 only
- ☐ 1, 2 and 3 only
- ☐ 1, 3 and 4 only

76 Which of the statements about the genetic modification of a bacterium to produce human insulin are correct?

- 1 Human insulin DNA is cut out using an enzyme.
- 2 This DNA is inserted into the nucleus of a bacterium.
- 3 The modified bacterium is cultured.
- 4 The bacterial cells are injected into humans with diabetes.

- A 1 and 2 only
- B 1 and 3 only
- C 2 and 4 only
- D 3 and 4 only
- E 1, 2 and 3 only
- F 1, 3 and 4 only



68 SCID is an inherited condition in humans.

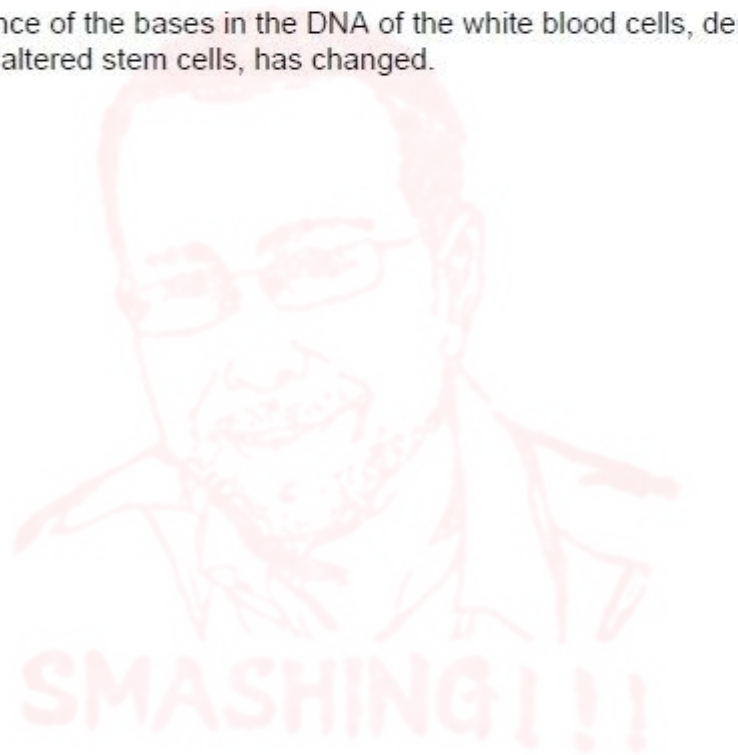
In one type of SCID, the white blood cells are unable to make the functional enzyme ADA, which is necessary for these cells to divide by mitosis during an immune response.

Scientists have developed a gene therapy treatment whereby a gene is inserted into the DNA of stem cells taken from the bone marrow of a person with this condition. These cells can then be returned to the body of the person, and can divide and differentiate into white blood cells. If this gene therapy is successful, the number of white blood cells should increase significantly.

Which of the following statements correctly describe(s) how this method of gene therapy might work to help a person with this type of SCID?

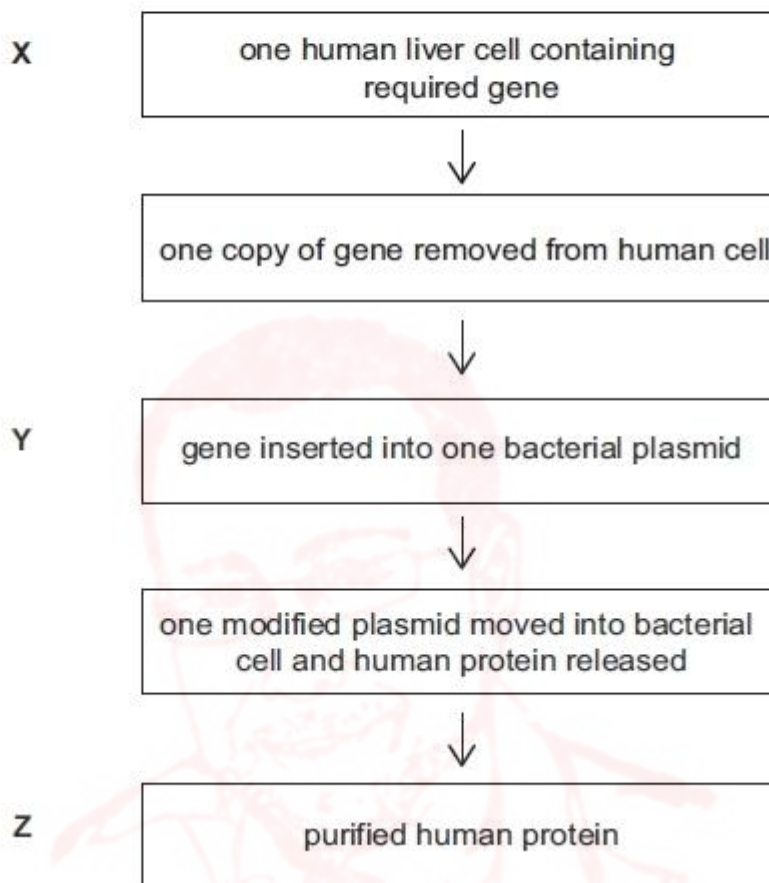
- 1** Genetically altered stem cells differentiate into white blood cells that are able to produce functional ADA.
- 2** Genetically altered stem cells can differentiate into gametes so that offspring will not inherit SCID.
- 3** The sequence of the bases in the DNA of the white blood cells, derived from the genetically altered stem cells, has changed.

- A** 1 only
- B** 2 only
- C** 3 only
- D** 1 and 2 only
- E** 1 and 3 only
- F** 2 and 3 only
- G** 1, 2 and 3



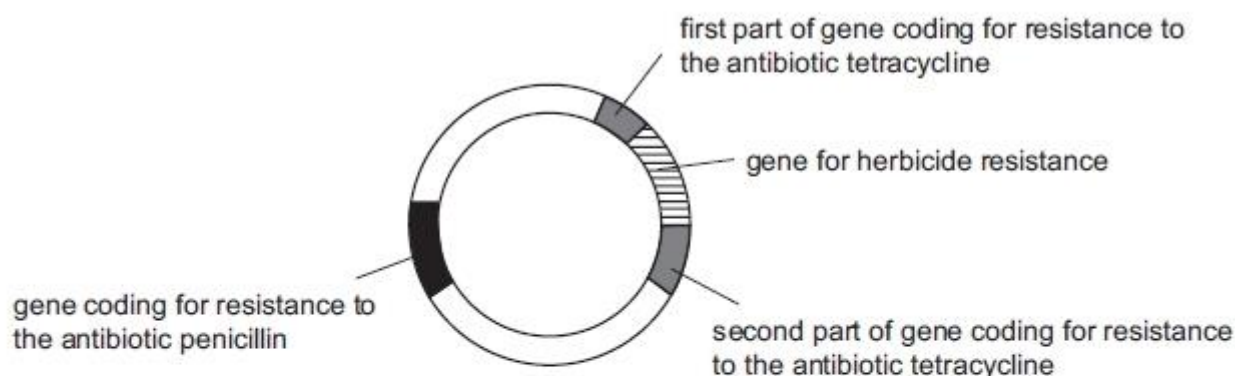
- 62** A bacterium was genetically modified by inserting a human gene into a plasmid. A plasmid is a small circle of DNA that can be used to transfer genes into bacterial cells. These modified bacteria then secrete the protein that the human gene codes for. The gene contains a sequence of bases that is not repeated anywhere else in its DNA and is not found in the DNA of other organisms. This sequence of bases is found in every allele of this gene.

Assuming that no mutations occur, how many copies of this base sequence would you expect to find at each of the stages X, Y and Z?



	number of copies of DNA sequence found		
	stage X	stage Y	stage Z
A	1	1	0
B	1	2	1
C	1	1	1
D	2	1	0
E	2	1	1
F	2	2	0

- 68 The diagram below shows a circular piece of bacterial DNA called a plasmid that has been made recombinant by the insertion of a plant gene for herbicide resistance.



Bacteria containing only the recombinant plasmid had to be identified from bacteria that contained only the original plasmid. The original plasmid contained a gene coding for resistance to the antibiotic penicillin and a gene coding for resistance to the antibiotic tetracycline.

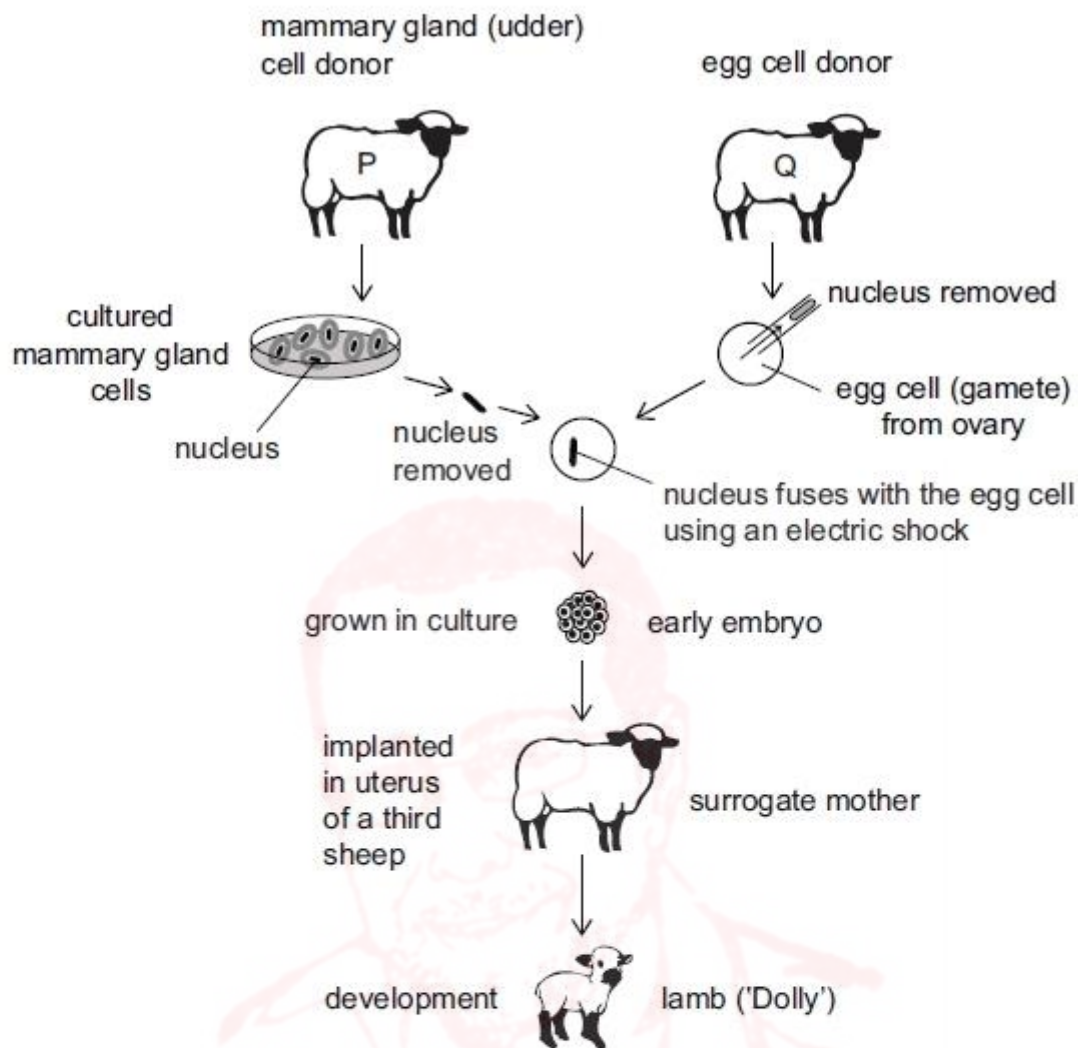
These bacteria were grown on two sets of agar plates. One set used agar that contained the antibiotic penicillin and the other set used agar that contained the antibiotic tetracycline.

Which row in the table correctly shows the growth of these bacteria on the two sets of agar?

	<i>bacteria containing only</i>	<i>growth on agar containing penicillin</i>	<i>growth on agar containing tetracycline</i>
A	recombinant plasmid	yes	yes
	original plasmid	no	no
B	recombinant plasmid	yes	yes
	original plasmid	yes	no
C	recombinant plasmid	yes	no
	original plasmid	yes	yes
D	recombinant plasmid	no	no
	original plasmid	yes	yes
E	recombinant plasmid	yes	yes
	original plasmid	no	yes
F	recombinant plasmid	no	no
	original plasmid	no	no
G	recombinant plasmid	yes	no
	original plasmid	no	yes

66 Dolly the sheep was born in 1996. She was unusual because she had no biological father.

The diagram shows how she was produced.



Which of the following processes had to occur to produce Dolly?

- 1 genetic engineering
- 2 mitosis
- 3 meiosis
- 4 differentiation

- A 1 and 2 only
- B 2 and 3 only
- C 1, 2 and 4 only
- D 1, 3 and 4 only
- E 2, 3 and 4 only

69 Which of the statements about the genetic modification of a bacterium to produce human insulin are correct?

- 1 Human insulin DNA is cut out using an enzyme.
- 2 This DNA is inserted into the nucleus of a bacterium.
- 3 The modified bacterium is cultured.
- 4 The bacterial cells are injected into humans with diabetes.

- A 1 and 2 only
- B 1 and 3 only
- C 2 and 4 only
- D 3 and 4 only
- E 1, 2 and 3 only
- F 1, 3 and 4 only

Section 2 Questions

The order when you should complete these questions in:

To find IB Higher Level Biology MCQ questions a program called IB Question Bank can help.

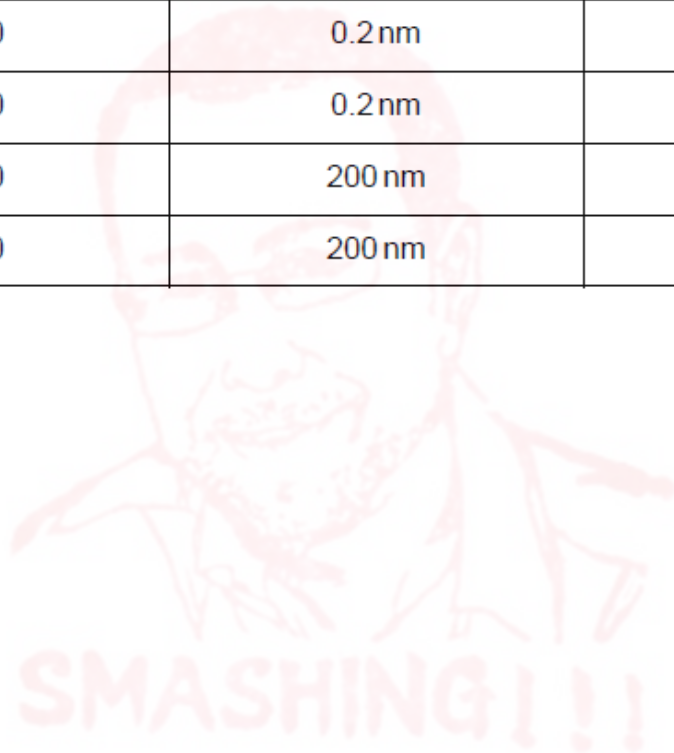
1. Get really good at AS (and IB HL) MCQ questions.
2. Then try Section 1 questions, if you are really good at these, continue.
3. If struggling with Section 1 questions, go back and try again to get really good at AS/A2 and IB questions in the same topic.
4. If really good at Section 1 questions, complete all of them.
5. Make sure your personal statement is finished, or nearly finished.
6. Make sure you have started to prepare for the interview by talking in English about biology, ideally with a teacher, and ideally with a teacher who has experience helping students with Oxbridge applications.
7. Then try Section 2 MCQ questions only, remember they have 180 seconds instead of about 90 seconds each.
8. If you are really good at Section 2 MCQs, complete them for all AS topics and A2 Topics that are on the ESAT syllabus.
9. Finally, complete the short answer questions for all topics on the ESAT syllabus.
10. Complete all Section 1 questions again.
11. Complete all Section 2 questions, including the short answer questions for all topics on the ESAT syllabus.
12. Make sure your personal statement is complete.
13. Make sure you are confident and performing well in mock interviews.
14. Now you could then try Section 2 questions on topics that will not appear in your ESAT, including the short answer questions on A2 material not on the ESAT syllabus.



47 The table identifies various values relating to microscopy.

Which row in the table is correct?

	<i>the maximum useful magnification of a light microscope</i>	<i>the resolution limit of a transmission electron microscope</i>	<i>the actual diameter of an adenovirus pathogen based on a 1×10^6 magnified image with a diameter of 20 mm</i>
A	$\times 150$	0.2 nm	20 nm
B	$\times 150$	0.2 nm	20 μm
C	$\times 150$	200 nm	20 nm
D	$\times 150$	200 nm	200 nm
E	$\times 1500$	0.2 nm	20 nm
F	$\times 1500$	0.2 nm	200 nm
G	$\times 1500$	200 nm	20 μm
H	$\times 1500$	200 nm	200 nm



- 48** Complete ribosomes are made from one large subunit and one small subunit joined together. The subunit names are based on their sizes as shown in the table.

<i>size of ribosomal subunit</i>	<i>name of subunit in eukaryotes</i>	<i>name of subunit in prokaryotes</i>
small	40S	30S
large	60S	50S

In a study, scientists found that one organism made and assembled the subunits in its nucleus. The complete ribosome was then transported to the cytoplasm.

Which row is correct?

	<i>name of the large subunit in the complete ribosome studied</i>	<i>components found in the ribosomal subunits</i>
A	50S	amino acids and no nucleotide bases
B	50S	adenine, cytosine, guanine, thymine
C	50S	amino acids, adenine, cytosine, guanine, thymine
D	50S	amino acids, adenine, cytosine, guanine, uracil
E	60S	amino acids and no nucleotide bases
F	60S	adenine, cytosine, guanine, thymine
G	60S	amino acids, adenine, cytosine, guanine, thymine
H	60S	amino acids, adenine, cytosine, guanine, uracil

52 A scientist conducts an experiment to study a single-celled organism in a growth tube.

The organism divides once every 50 minutes using binary fission. Binary fission produces the same number of daughter cells per division as a cell dividing by mitosis.

The scientist starts with 150 cells. The experiment is left for 300 minutes.

The average volume of every cell is $5\mu\text{m}^3$.

To ensure there are sufficient nutrients available for the cells, the final volume of cells within the tube must not be more than 1% of the total volume of material inside the tube.

What is the minimum volume of nutrient solution required inside the growth tube at the start of the experiment?

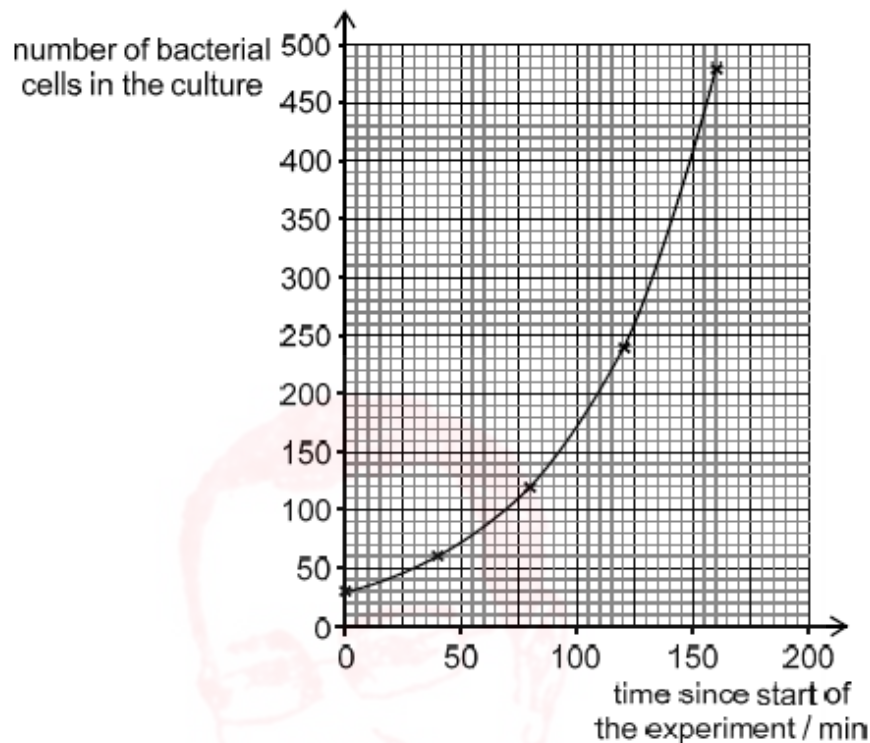
(Assume that all the cells are alive and capable of dividing.)

- A $4.8 \times 10^{-3} \text{ mm}^3$
- B $9.5 \times 10^{-3} \text{ mm}^3$
- C $3.1 \times 10^{-1} \text{ mm}^3$
- D $4.8 \times 10^{-1} \text{ mm}^3$
- E $9.5 \times 10^{-1} \text{ mm}^3$
- F $9.5 \times 10^2 \text{ mm}^3$
- G $4.8 \times 10^3 \text{ mm}^3$
- H $3.1 \times 10^5 \text{ mm}^3$



- 53** Bacterial cells were grown in a laboratory experiment and the number of cells was recorded at regular intervals. The bacteria in this experiment reproduced asexually using a form of cell division. The growth medium was sterilised before it was used and the vessel containing the bacterial cells was sealed so that no other cells could enter.

The graph shows the results of the experiment.



Which of the following statements is/are correct?

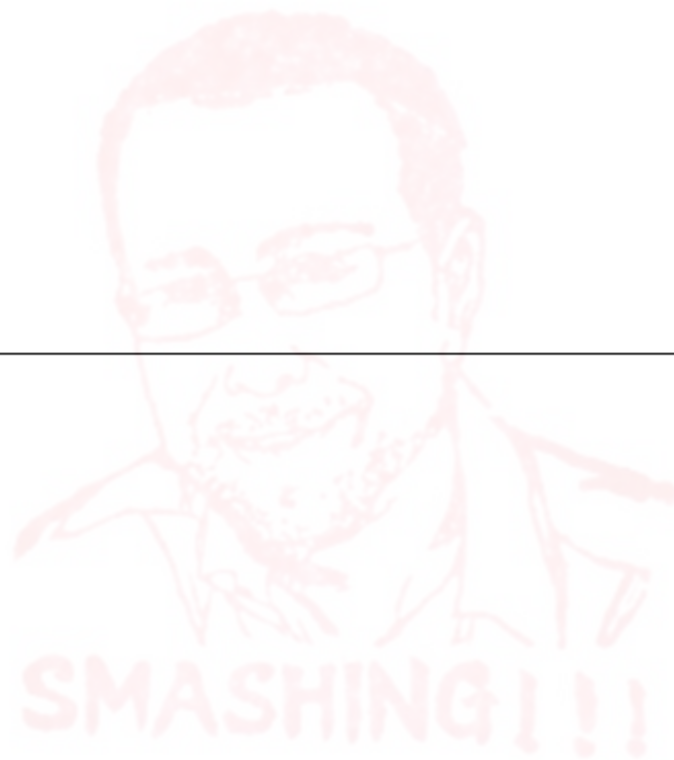
- 1 After 4 hours, assuming that the rate of growth continues on the same curve, the predicted number of cells in the experiment is 1920.
 - 2 During the 80 minutes after the start of the experiment there was a 400% increase in the number of cells.
 - 3 The growth curve is of the form $y = 30k^x$
- A none of them
- B 1 only
- C 2 only
- D 3 only
- E 1 and 2 only
- F 1 and 3 only
- G 2 and 3 only
- H 1, 2 and 3

Question B1

- a) Sketch a simple diagram of a eukaryotic cell, and label the locations where DNA transcription and RNA translation take place.

[2 marks]

Answer:

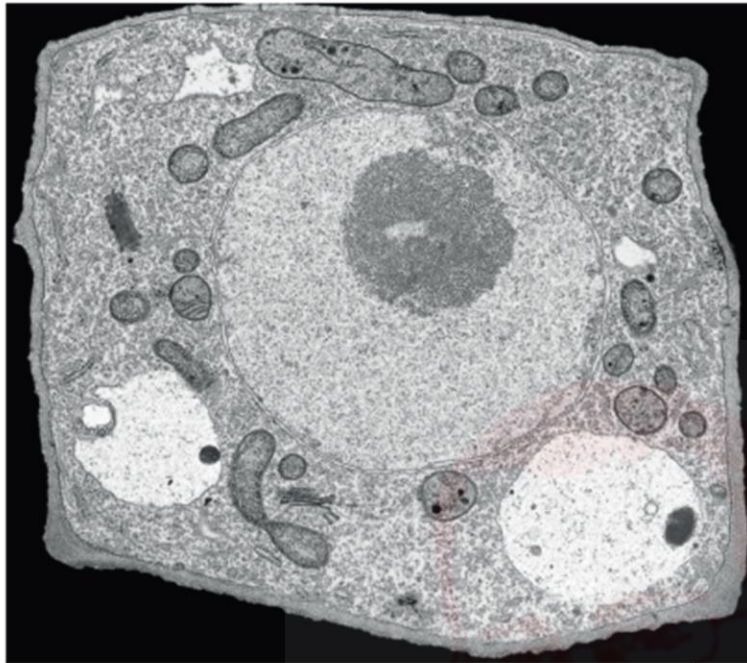


Question B1

a) Identify the types of cells that can be seen in Fig. (i) and (ii).

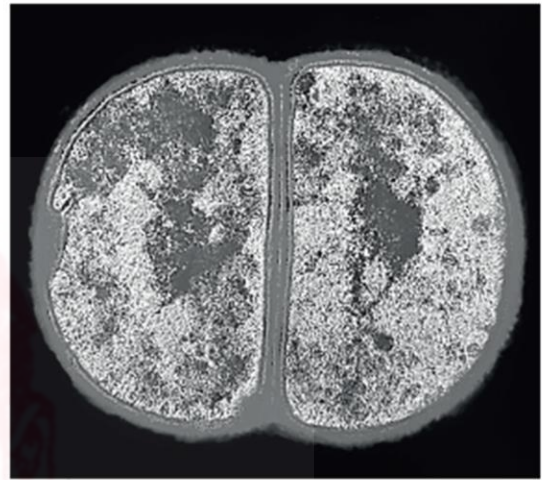
[2 marks]

Fig. (i)



20 μm

Fig. (ii)



0.5 μm

Answer:

(i)

(ii)

b) Why was an electron microscope used to create these images?

[1 mark]

Answer:

.....

.....

.....

c) Assume that the scale bar below each image is 3 cm long.

Estimate the magnification of each image.

[2 marks]

Answer:

(i)

(ii)

d) Discuss the evolutionary order of appearance of the mitochondrion, chloroplast and ribosome, explaining your reasoning.

[3 marks]

Answer:

e) Estimate the percentage of the volume of the cell that the nucleus takes up in Fig. (i), assuming that the cell can be approximated as a cube and the nucleus as a sphere.

(The volume of a sphere is $\frac{4}{3}\pi r^3$ where r is the radius of the sphere.)

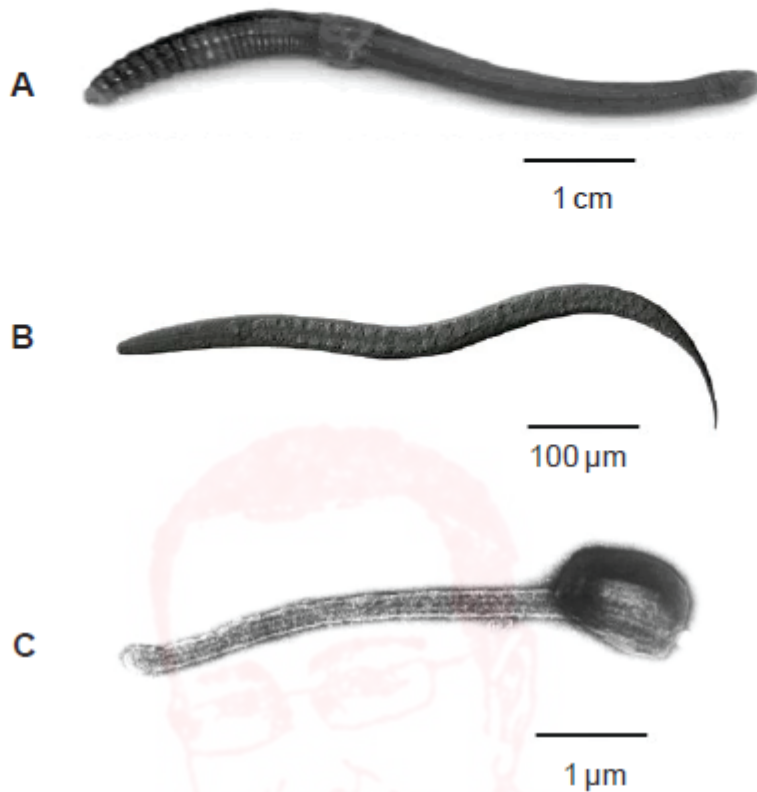
[2 marks]

Answer:



Question 6

Below are images of three species of organism, all of which are vermiform (worm-like) in appearance.



a) What is the approximate length of each species in mm?

[3 marks]

Answer:

A.....

B.....

C.....

b) What type of microscope has been used to produce the images of organisms B and C?

[2 marks]

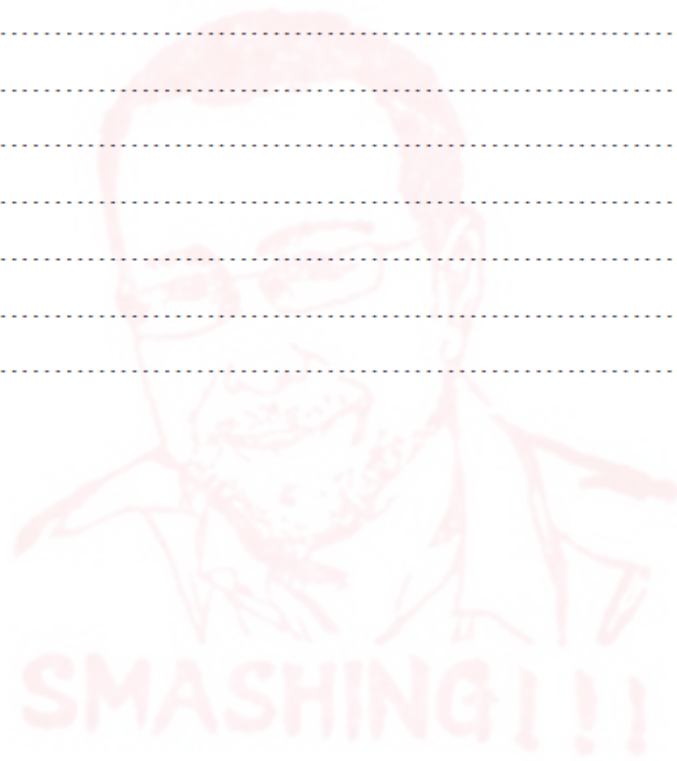
Answer:

B.....

C.....

- c) For organism A, treating it as a tube, estimate the surface area:volume ratio, working in mm. Show your working. [4 marks]

Answer:



d) How will the surface area:volume ratio differ between the three organisms?

[2 marks]

Answer:

.....

.....

.....

.....

.....

.....

.....

e) Identify four substances that organism A may need to exchange with the external environment.

[2 marks]

Answer:

.....

.....

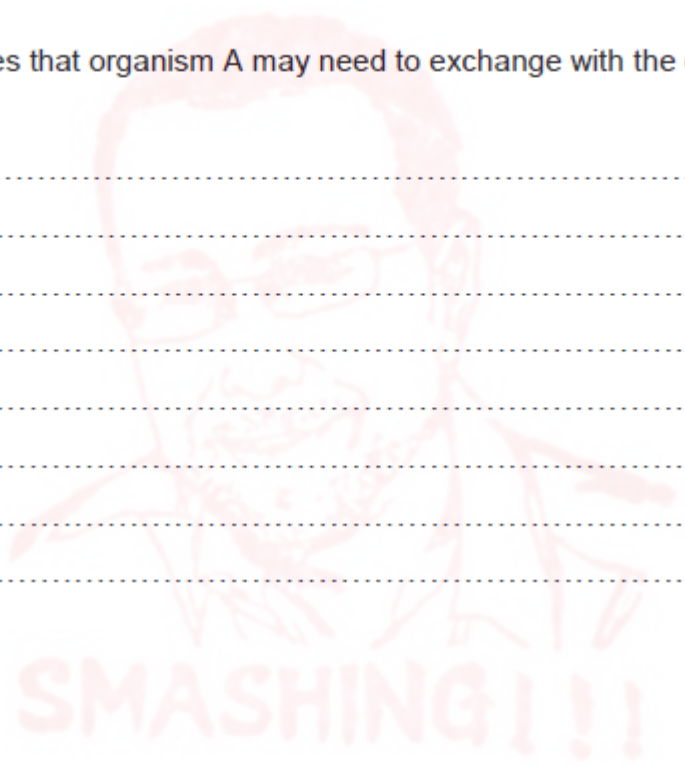
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.....

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.....

.....



21 Stearic acid is a fatty acid. It contains 18 carbon atoms and zero carbon–carbon double bonds.

It can be represented by the notation C18:0, where 18 is the number of carbons and 0 is the number of carbon–carbon double bonds present.

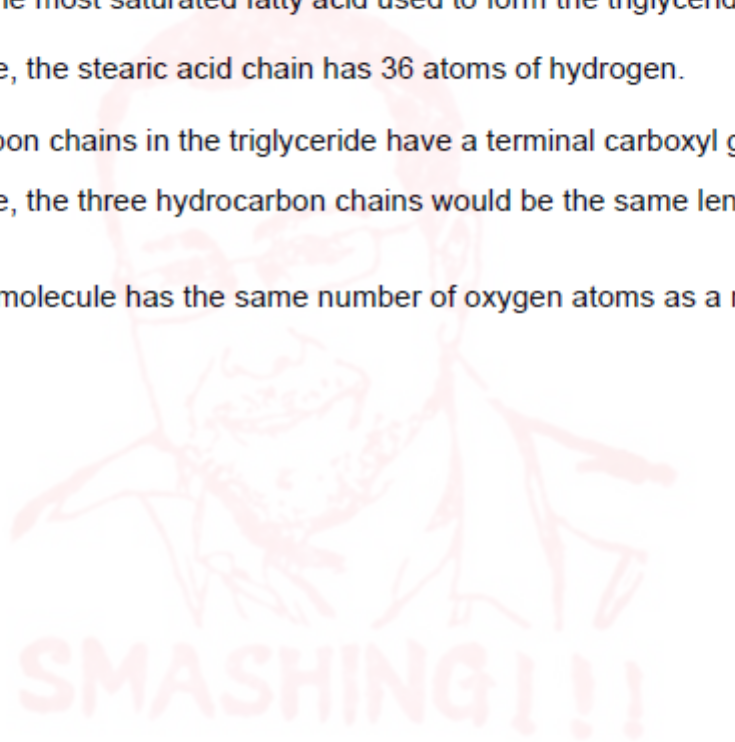
The table shows this notation for two other fatty acids:

<i>fatty acid</i>	<i>notation</i>
oleic	C18:1
linoleic	C18:2

A triglyceride was formed using one of each of the three fatty acids.

Which statement about this triglyceride is correct?

- A Linoleic acid is the most saturated fatty acid used to form the triglyceride.
- B In the triglyceride, the stearic acid chain has 36 atoms of hydrogen.
- C All the hydrocarbon chains in the triglyceride have a terminal carboxyl group.
- D In the triglyceride, the three hydrocarbon chains would be the same length and parallel to each other.
- E The triglyceride molecule has the same number of oxygen atoms as a molecule of glucose.



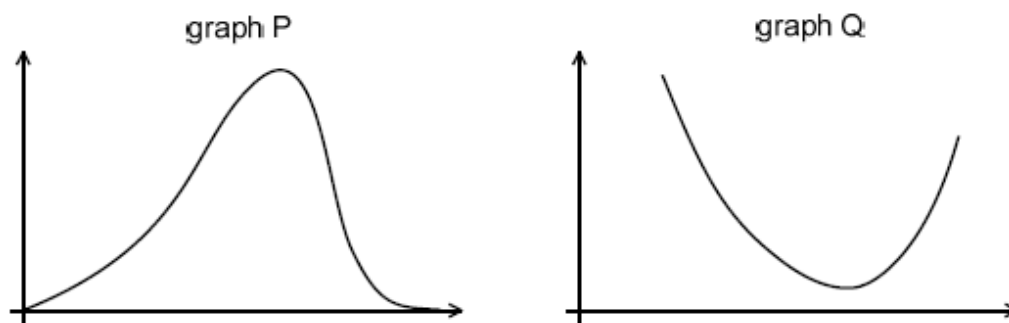
41 A solution containing sucrose, starch and amylase was incubated at 37 °C. After the reactions had completed, the student divided the solution into three test tubes and carried out the following tests:

- add biuret reagent
- add iodine solution
- add Benedict's solution and heat

Which row shows the final colours after the tests?

	<i>add biuret reagent</i>	<i>add iodine solution</i>	<i>add Benedict's solution and heat</i>
A	purple	yellow-brown	blue
B	purple	blue-black	red
C	purple	yellow-brown	red
D	purple	blue-black	blue
E	blue	yellow-brown	blue
F	blue	blue-black	red
G	blue	yellow-brown	red
H	blue	blue-black	blue

- 43** Graphs P and Q were plotted using data collected in an investigation into the effect of temperature from 0 to 60 °C on an enzyme-controlled reaction. All other variables were controlled.



Which two rows correctly identify the variables plotted on the horizontal and vertical axes of these graphs?

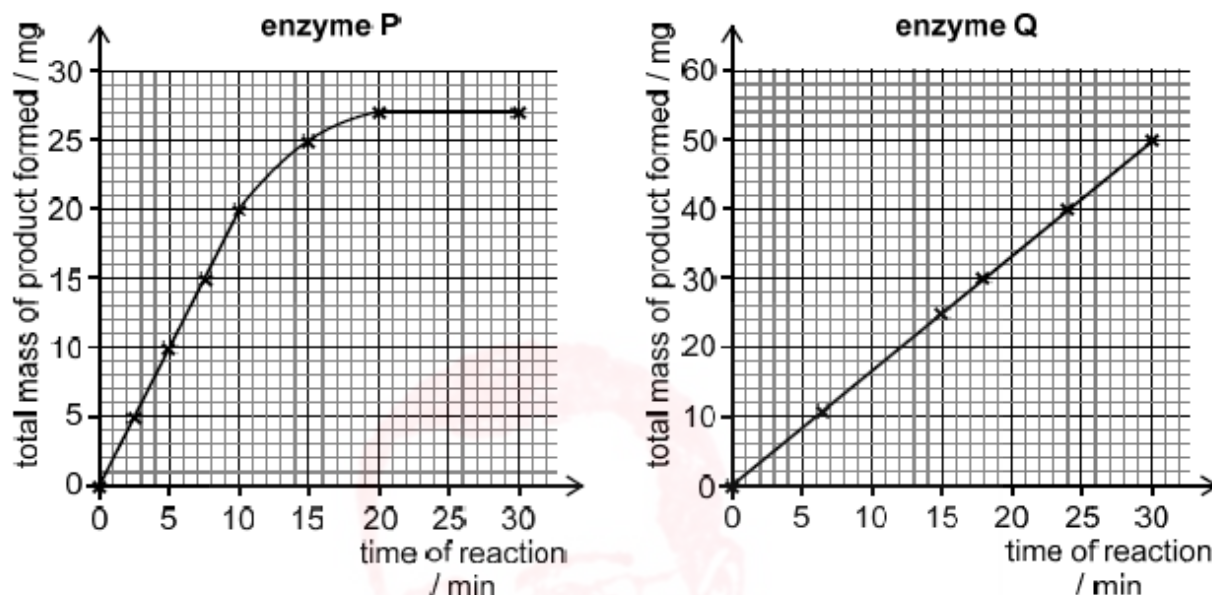
row	graph	horizontal axis	vertical axis
1	P	temperature	time taken for reaction
2	P	temperature	rate of reaction
3	P	time taken for reaction	temperature
4	P	time taken for reaction	rate of reaction
5	Q	temperature	time taken for reaction
6	Q	temperature	rate of reaction
7	Q	time taken for reaction	temperature
8	Q	time taken for reaction	rate of reaction

- A** 1 and 2
B 1 and 7
C 2 and 5
D 2 and 6
E 3 and 5
F 3 and 8
G 4 and 7
H 4 and 8

- 50** Experiments were carried out to investigate the rate at which products were formed by two digestive enzymes, P and Q over a period of 30 minutes.

P and Q have similar optimum conditions for function. Only the enzyme and its substrate were changed between each reaction.

The results are shown in the graphs.



Which of the following statements is/are correct?

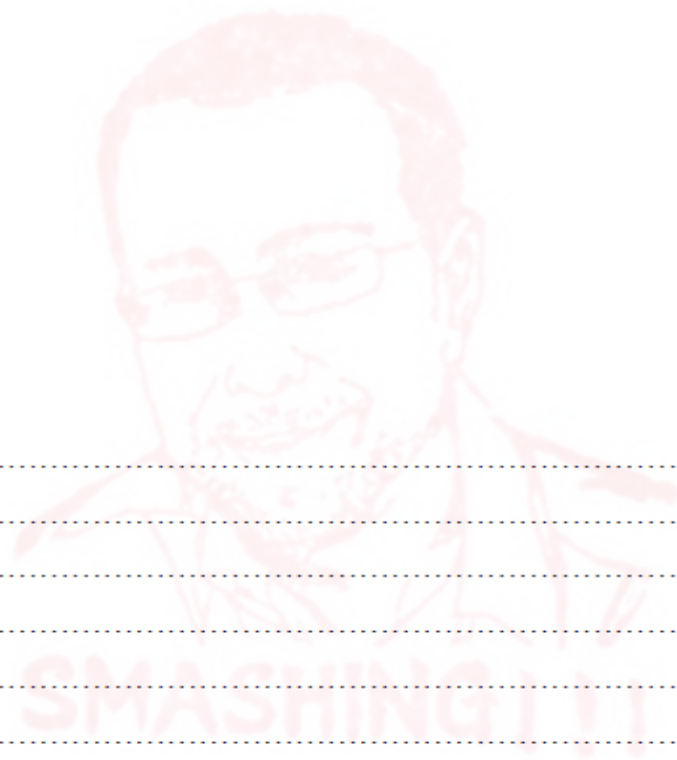
- 1 During the first 10 minutes, the rate of reaction (mg min^{-1}) with enzyme P is double the rate with enzyme Q.
- 2 A possible explanation for the difference in the shape between the graphs is that the product of the reaction catalysed by P significantly alters the pH of the solution.
- 3 The percentage change in mass of product formed by enzyme Q is more than 5 times greater between 6.5 and 15 minutes than it is between 24 and 29 minutes.

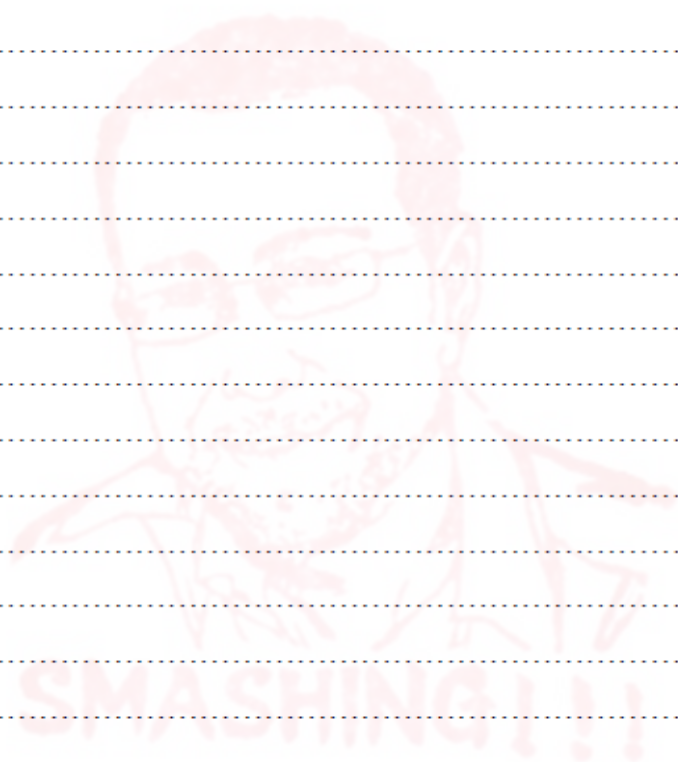
- A none of them
- B 1 only
- C 2 only
- D 3 only
- E 1 and 2 only
- F 1 and 3 only
- G 2 and 3 only
- H 1, 2 and 3

- g) Discuss how temperature might affect net CO₂ uptake in plants, with reference to the effects of temperature on enzymatic activity. Use graphs to illustrate your answer.

[10 marks]

Answer:





Biology

Question 5

EcoRI is a restriction enzyme that cuts bacterial DNA into pieces at specific sequences.

- g) *EcoRI* is produced by bacteria that often live harmlessly inside the human body. Explain how temperature and pH might affect the activity of *EcoRI* in bacterial cells, using diagrams if necessary. [12 marks]

Answer:

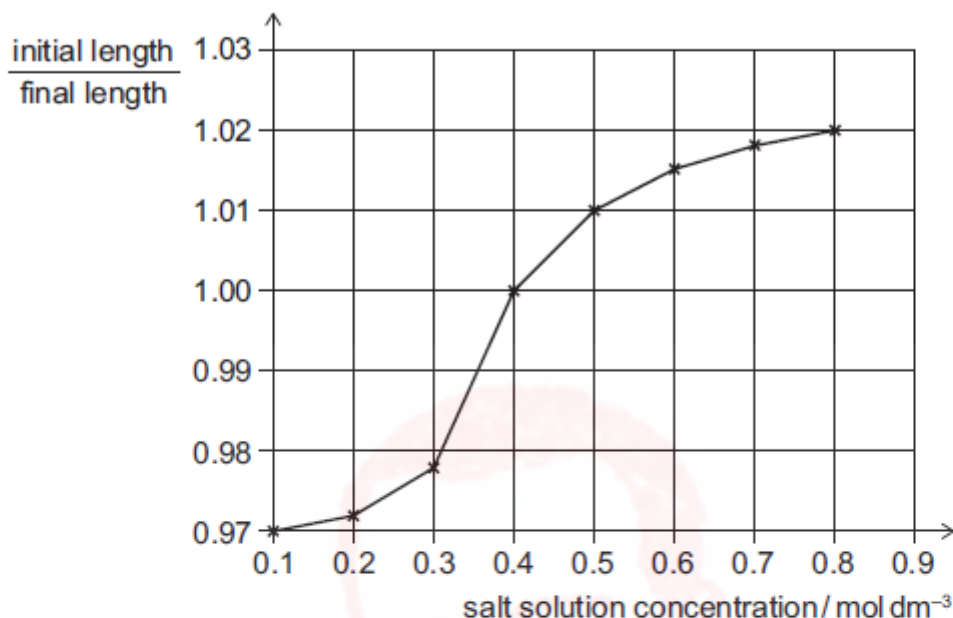
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- 23** A student placed 5 cm long identical pieces of plant tissue into a range of different concentrations of salt solution. After one hour, the pieces were removed from the solutions and the length of each piece measured.

For each piece the initial length was divided by the final length, and these values were plotted on a graph against salt solution concentration.



Which concentration of salt solution has the same water potential as the cell sap of the plant tissue, and what was the change in length, in mm, of the plant tissue placed in the 0.1 mol dm⁻³ salt solution?

	concentration of salt solution with the same water potential as the cell sap / mol dm ⁻³	change in length of plant tissue in 0.1 mol dm ⁻³ salt solution / mm
A	0.8	-0.15
B	0.8	-1.5
C	0.8	+1.5
D	0.4	-1.5
E	0.4	+0.15
F	0.4	+1.5
G	0.1	-0.15
H	0.1	+0.15

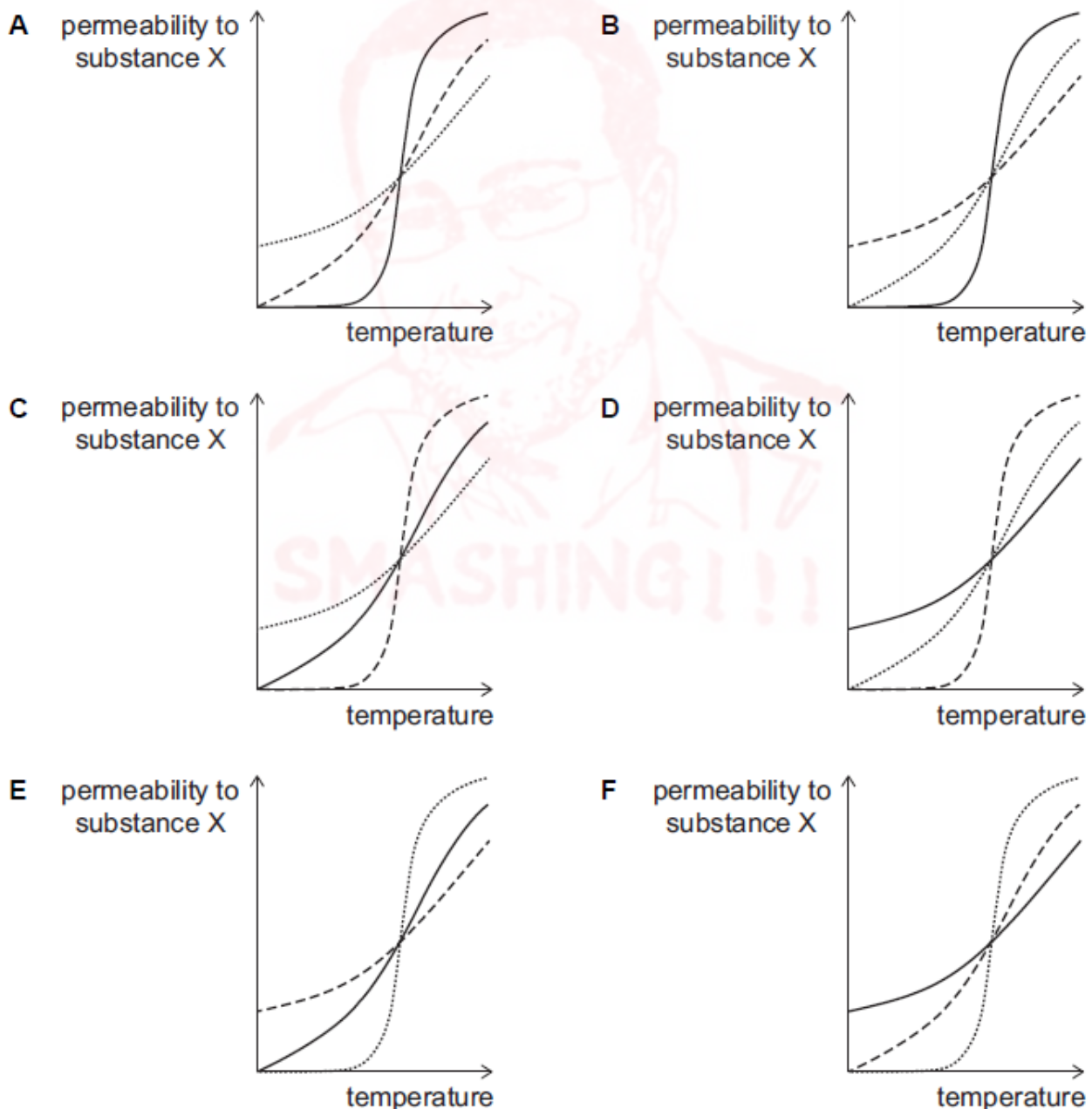
52 The properties of three biological membranes were investigated. It was found that:

- There is a positive correlation between the fluidity of a membrane and the rate of simple diffusion of substance X across it.
- Cholesterol increases the fluidity of membranes at low temperatures, but decreases their fluidity at high temperatures.
- The cell surface membrane has the highest percentage of cholesterol, and the lysosomal membrane has the second highest percentage of cholesterol.

Which of the following sketch graphs is consistent with this information?

Key

- Golgi apparatus membrane
- inner mitochondrial membrane
- cell surface membrane

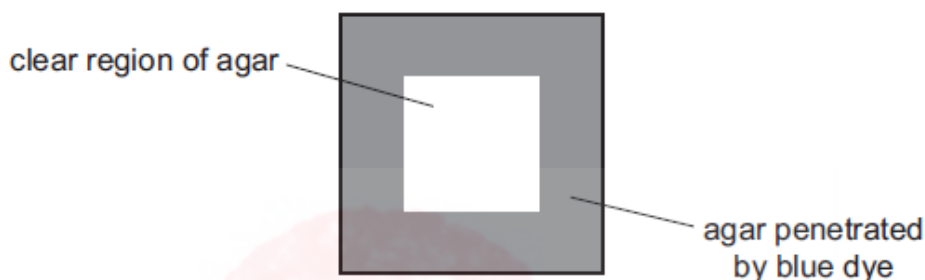


- 56** A student investigated the effect of increasing the size of an agar (a jelly-like substance) cube on its efficiency to absorb and distribute a blue dye.

Two agar cubes were prepared, one with side lengths of 1 cm and the other with side lengths of 3 cm. They were put in a solution of blue dye for 30 minutes.

The cubes were then removed from the dye and cut in half to measure the penetration of the dye into the agar.

In the 3 cm cube the dye had penetrated to a depth of 0.75 cm. The cross section of this cube is shown:



[diagram not to scale]

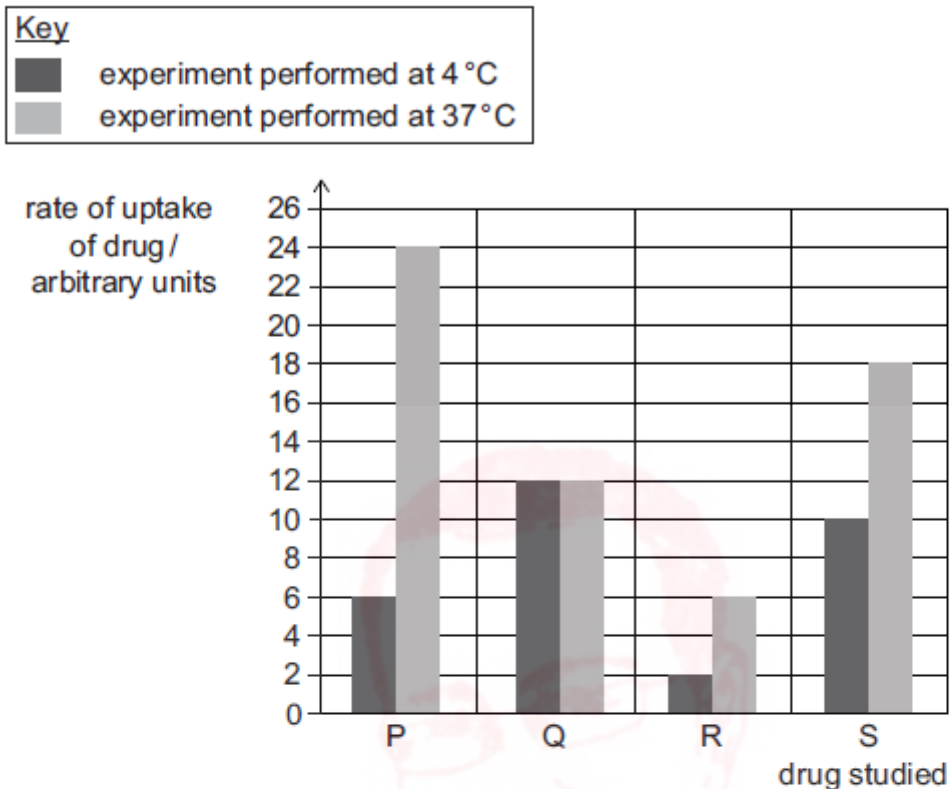
When the cube with sides of 1 cm was cut in half, all the agar had been penetrated with the dye.

Which row is correct for this investigation?

	<i>percentage of the volume of the 3 cm cube penetrated by the dye</i>	<i>change in surface area : volume ratio as cube size increases</i>	<i>process(es) to describe the movement of the blue dye into the cube</i>
A	12.5	increases	active transport and osmosis
B	75.0	increases	diffusion and osmosis
C	87.5	decreases	diffusion only
D	12.5	decreases	diffusion and osmosis
E	75.0	decreases	diffusion only
F	87.5	increases	diffusion and osmosis
G	75.0	increases	active transport and osmosis
H	87.5	decreases	active transport and osmosis

57 Scientists studied the processes by which drugs cross the cell membrane and enter cells.

The rate of uptake of four drugs, P, Q, R and S, was studied at 4 °C and at 37 °C. The results are shown in the chart. All other variables were kept constant.



Which of the following conclusions can be drawn from the results?

- 1 The percentage increase in rate of uptake of R from 4 °C to 37 °C is 2.5 times more than the percentage increase in the rate of uptake of S.
- 2 The concentration of Q must be the same inside and outside the cell.
- 3 P must be transported across the cell membrane using active transport only.

- A** none of them
- B** 1 only
- C** 2 only
- D** 3 only
- E** 1 and 2 only
- F** 1 and 3 only
- G** 2 and 3 only
- H** 1, 2 and 3

- 22** An investigation was carried out to study the effect of varying the concentration of sugar solution on osmosis in potato tissue.

The masses of six cylinder-shaped pieces of raw potato were measured.

Each piece was then placed in a different concentration of sugar solution. Each piece was left in its solution for an equal amount of time. All other variables were kept constant.

The pieces were removed from the solutions and their masses were measured again. The results are shown in the table.

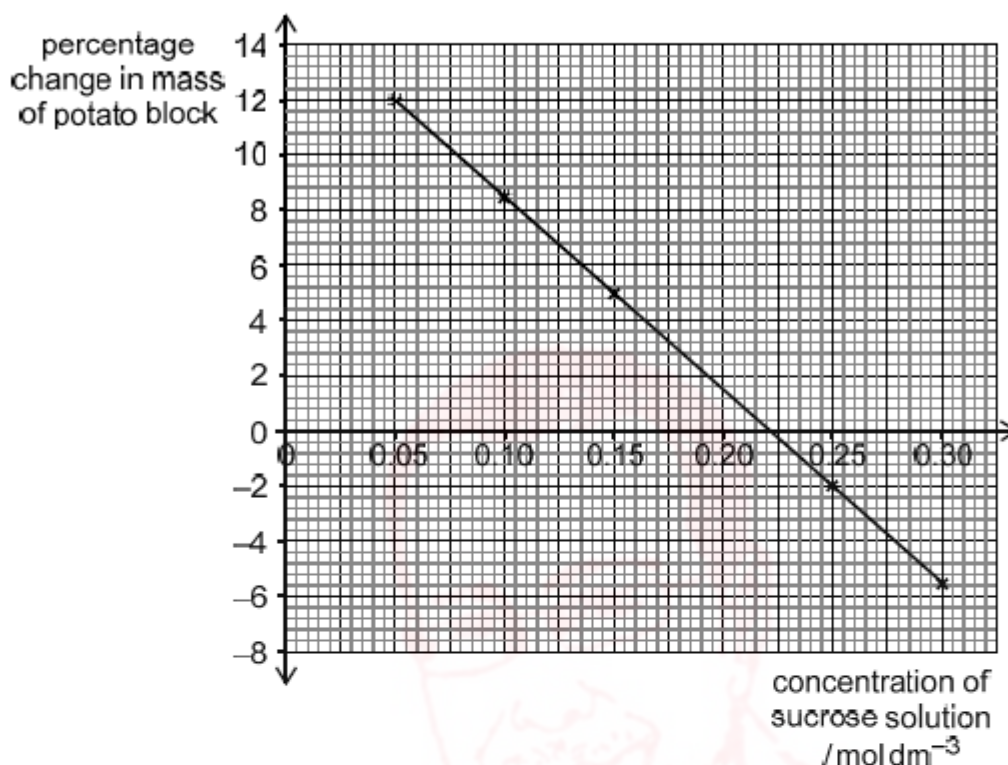
<i>concentration of sugar solution / mol dm⁻³</i>	<i>mass of potato piece at start / g</i>	<i>mass of potato piece at end / g</i>
0.0	3.82	4.09
0.2	3.90	3.84
0.4	3.80	2.96
0.6	3.93	2.62
0.8	3.77	2.43
1.0	3.78	2.44

What is the percentage change in mass when the concentration is 0.6 mol dm⁻³, and which solution has a concentration closest to that of the cytoplasm of the potato cells?

	<i>percentage change for the 0.6 mol dm⁻³ solution</i>	<i>solution concentration closest to that of cytoplasm</i>
A	33% decrease	0.2 mol dm ⁻³
B	50% increase	0.2 mol dm ⁻³
C	67% increase	0.2 mol dm ⁻³
D	33% decrease	0.4 mol dm ⁻³
E	50% increase	0.4 mol dm ⁻³
F	67% increase	0.4 mol dm ⁻³

- 46** Equal-sized, rectangular blocks of a raw potato were cut and their mass measured. The blocks were then placed in equal volumes of different concentrations of sucrose solutions for the same length of time. All other variables were kept constant.

After this time, the blocks were blotted on paper and then their masses were measured again. The percentage change in mass of each block was calculated and the results are shown in the graph.

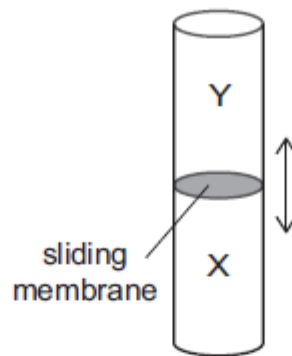


Which of the following statements is/are correct?

- 1 In 0.10 mol dm⁻³ sucrose solution, there was some movement of sucrose molecules by osmosis across the membrane out of the potato block.
- 2 If the initial mass of the block in 0.25 mol dm⁻³ sucrose solution is 1.800 g then its final mass will be 1.764 g.
- 3 Repeating the experiment at a temperature that was 10°C lower should not affect the point at which the graph crosses the x-axis.

- A none of them
- B 1 only
- C 2 only
- D 3 only
- E 1 and 2 only
- F 1 and 3 only
- G 2 and 3 only
- H 1, 2 and 3

- 58** The diagram shows a cylinder with two compartments, X and Y, separated by a sliding partial permeable membrane which is impermeable to glucose.



Compartment X contains 100 mmol dm^{-3} glucose solution and compartment Y contains 200 mmol dm^{-3} glucose solution. The initial volume of the solution in each of the two compartments is the same, 10 cm^3 .

After three hours, there is no further change in the volumes of X and Y.

Which of the following statements describe(s) the results of the experiment?

- 1 The volume of Y increases during the first three hours.
- 2 During the first three hours, the average rate of osmosis is $\frac{10}{9} \text{ cm}^3$ per hour.
- 3 During the first three hours, the average rate of change in glucose concentration in compartment X is 50 mmol dm^{-3} per hour.

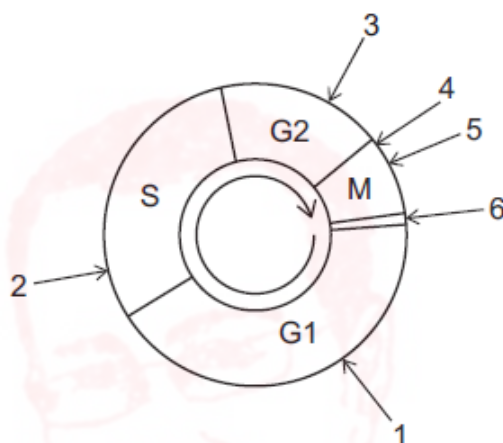
- A 1 only
B 2 only
C 3 only
D 1 and 2 only
E 1 and 3 only
F 2 and 3 only
G 1, 2 and 3

51 Some chemotherapy drugs interfere with the mitotic cell cycle.

The following table lists five chemotherapy drugs and their mechanisms of action.

<i>chemotherapy drug</i>	<i>mechanism of action</i>
Dinaciclib	prevents cells progressing beyond prophase
Doxorubicin	prevents DNA repair following incorrect DNA replication
Methotrexate	inhibits enzymes responsible for DNA synthesis
Vinblastine	inhibits spindle fibre assembly
Wiskostatin	inhibits cytokinesis

The following diagram shows a simplified version of the mitotic cell cycle.



Which row identifies the position on the diagram where each chemotherapy drug is most likely to act?

	<i>Dinaciclib</i>	<i>Doxorubicin</i>	<i>Methotrexate</i>	<i>Vinblastine</i>	<i>Wiskostatin</i>
A	4	3	1	6	5
B	3	2	4	5	6
C	5	2	3	6	4
D	4	3	2	5	6
E	3	4	2	1	5
F	3	2	4	1	5
G	4	5	2	3	6

- 54** Three samples of cells were taken from the same healthy human: one sample from the blood, one sample from a kidney, and one sample from a testis.

Each sample contained five cells, three of one type and two of a different type. None of the cells were dividing.

In each sample, the mean number of chromosomes per cell was calculated. The results are shown in the table.

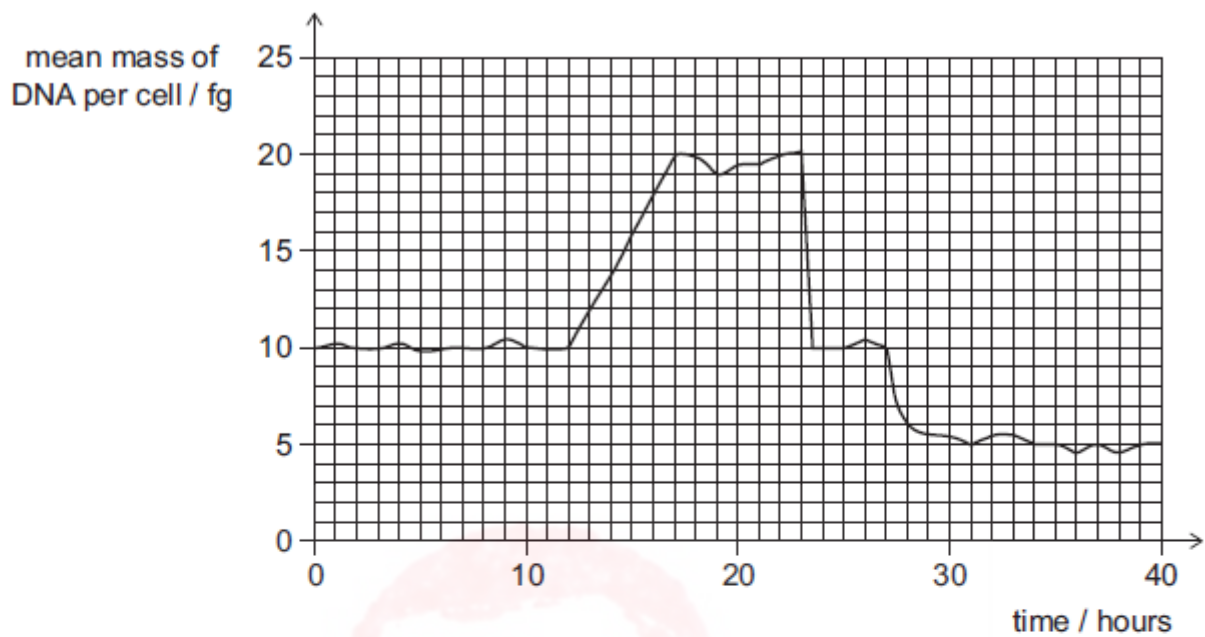
<i>sample</i>	<i>mean number of chromosomes per cell</i>
1	18.4
2	32.2
3	46.0

Which row in the following table identifies the samples from the kidney and the testis?

(Assume that no mutations occur in any of the cells in the samples.)

	<i>kidney</i>	<i>testis</i>
A	1	2
B	1	3
C	2	1
D	2	3
E	3	1
F	3	2

- 55** The graph shows the mean mass of DNA of a population of cells dividing at the same time, measured in femtograms (10^{-15} g) per cell.

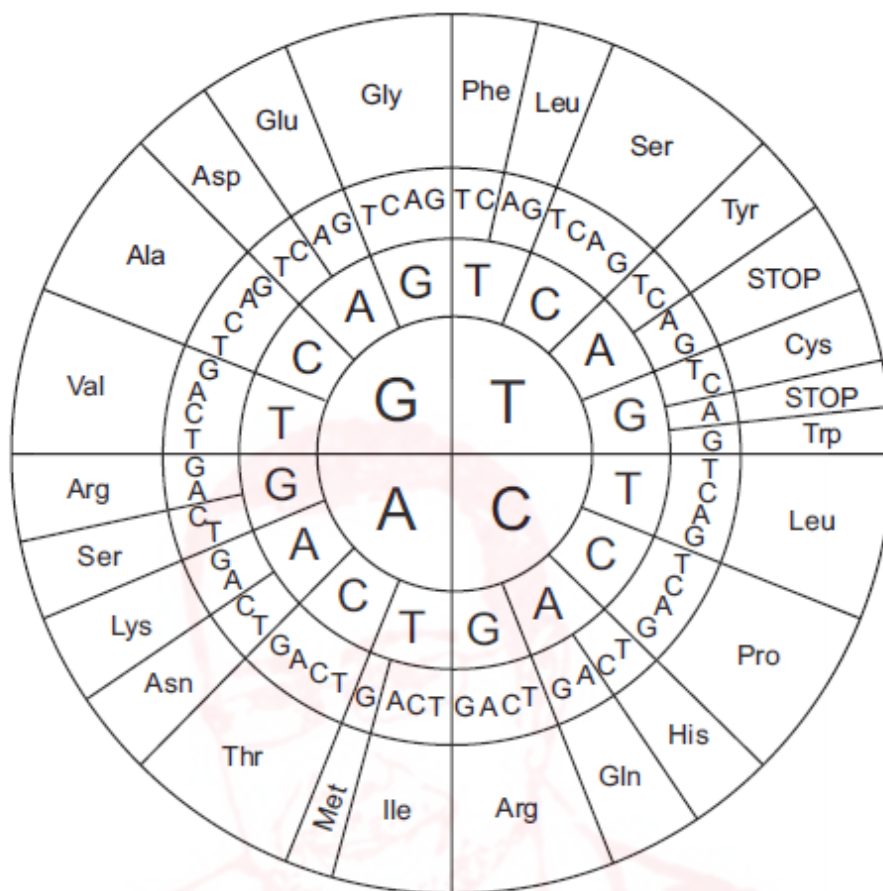


Which row in the table is correct?

	<i>type of cell division taking place</i>	<i>rate of DNA synthesis per cell between 12 and 17 hours / fg h⁻¹</i>	<i>period that could be part of interphase</i>
A	meiosis	2	0 to 17 hours
B	meiosis	0.5	0 to 17 hours
C	meiosis	2	12 to 24 hours
D	meiosis	0.5	12 to 24 hours
E	mitosis	2	0 to 17 hours
F	mitosis	0.5	0 to 17 hours
G	mitosis	2	12 to 24 hours
H	mitosis	0.5	12 to 24 hours

- 60** The genetic code is read in groups of three bases when coding for the synthesis of a protein. The diagram shows the base triplets within DNA that correspond to specific amino acids.

The diagram is read from the inside out. For example, the base triplets CAT and CAC both code for the amino acid histidine (His).



Assume that it is equally likely that mutations can change any base to any other base, and that the probability of this resulting in a change in any particular base during one cell division is 2×10^{-9} .

What is the probability that a triplet that codes for **Met** changes to code for **Pro** in one round of division?

- A $\frac{4}{9} \times 10^{-18}$
- B $\frac{4}{9} \times 10^{-9}$
- C $\frac{2}{3} \times 10^{-18}$
- D $\frac{2}{3} \times 10^{-9}$
- E 4×10^{-18}
- F 4×10^{-9}

b) When RNA is translated into protein, it is read in triplets (codons).

What proportion of codons might be viewed as redundant in the genetic code (i.e. in excess of the minimum needed to code for all amino acids)?

[2 marks]

Answer:

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- c) What is an advantage of having more codons in the genetic code than there are amino acids? **[2 marks]**

Answer:

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- d) A ribosome can translate 18 bases per second.

How many seconds would it take to produce a protein that was 299 amino acids long?

[2 marks]

Answer:

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- e) Imagine that an alien organism is found that translates its RNA using pairs of nucleotides instead of triplets.

During translation, the alien organism can use 50 possible amino acids (rather than the 20 found in humans).

What is the minimum number of different types of nucleotides that would be needed to code for all of the possible amino acids?

[2 marks]

Answer:

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Look at the following table.

	320										330										340									
Organism 1	G	C	C	T	A	G	G	C	A	T	T	A	C	G	C	T	A	C	G	T	C	G	C	A	T	T	A	T	A	C
Organism 2	G	C	T	A	A	G	G	C	A	C	T	A	C	G	C	T	A	C	G	T	C	G	C	T	T	A	A	T	A	G
Organism 3	G	C	T	A	A	G	C	A	C	T	A	C	G	C	T	A	C	G	T	C	G	C	T	T	A	A	T	A	G	C
Organism 4	G	C	T	A	A	G	G	C	A	C	T	A	C	G	C	T	A	C	G	T	C	G	C	A	T	T	A	T	A	C
Organism 5	G	C	C	A	A	G	G	C	A	C	T	A	C	G	C	T	A	C	G	T	C	G	C	A	T	T	A	T	A	C
Organism 6	G	C	T	A	A	G	G	C	A	C	T	A	C	G	C	T	A	C	G	T	C	G	C	T	T	T	A	T	A	C
Organism 7	G	C	T	A	A	G	A	G	A	C	T	A	C	G	G	A	A	C	G	C	C	G	C	T	T	A	A	T	A	G

- a) What does each horizontal line represent? [1 mark]

Answer:

- b) If the molecules represented above are transcribed, how would the sequences of the transcripts differ from the original sequences? (Note that you do not need to write out all of the transcripts.) [3 marks]

Answer:



c) Which of the sequences is least likely to lead to a functional part of a protein, and why? [3 marks]

Answer:

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Section 2 Topic 7 Q# 244/ Cambridge/2022sp/Section 2/ BIOLOGY NSAA/ www.SmashingScience.org

26 A student was investigating the vascular system in a flowering plant.

The student observed a photomicrograph showing a vascular bundle of this flowering plant, and identified features of a mature sieve tube element.

The cross-sectional area of a typical xylem vessel is six times greater than the cross-sectional area of this mature sieve tube element.

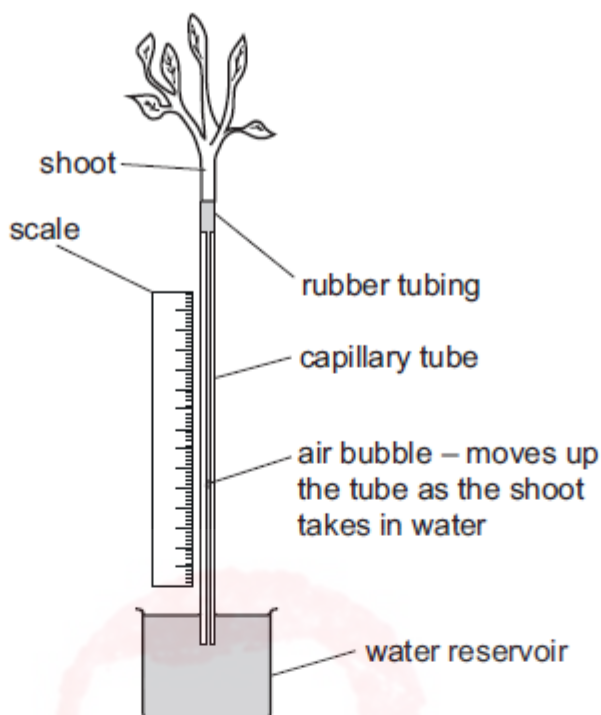
The cross-sectional area of a xylem vessel is $54\pi \mu\text{m}^2$.

Which row is correct for this mature sieve tube element?

(Assume that both cross-sectional areas are circular.)

	<i>outermost layer contains a structural polysaccharide</i>	<i>contains mitochondria</i>	<i>cross-sectional diameter of sieve tube element / μm</i>
A	yes	yes	3
B	yes	yes	6
C	yes	no	3
D	yes	no	6
E	no	yes	3
F	no	yes	6
G	no	no	3
H	no	no	6

27 The diagram shows apparatus that can be used to measure the water loss from a leafy shoot.



Three students, P, Q and R, each set up the apparatus and recorded how far the air bubble had moved in 15 minutes. It was observed that each student's apparatus had capillary tubing with a different internal diameter.

<i>student</i>	<i>distance bubble moved in 15 minutes / mm</i>	<i>internal diameter / mm</i>
P	90	0.60
Q	33	1.00
R	25	1.20

Which row shows the students' results from most water lost to least water lost, and what can be concluded about the observed results?

	<i>water lost from most to least</i>	<i>conclusion</i>
A	P Q R	the apparatus in P was placed in a humid environment
B	P Q R	there is insufficient information to explain the results
C	P R Q	the apparatus in P was placed in a hot dry environment
D	P R Q	there is insufficient information to explain the results
E	R Q P	the apparatus in R was placed in a humid environment
F	R Q P	there is insufficient information to explain the results
G	R P Q	the apparatus in R was placed in a hot dry environment
H	R P Q	there is insufficient information to explain the results

53 A 0.2 cm long section of xylem, with internal diameter 60 μm , was studied.

The velocity at which substances were transported through the xylem in a plant was found to be 3.6 metres per hour in the morning. Later in the day the velocity was greater.

Which row of the table is correct?

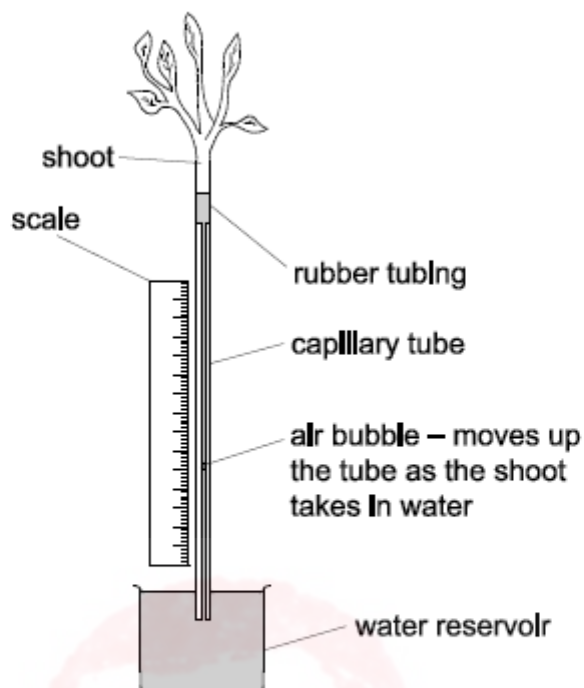
	<i>velocity of substance transport in the morning / $\mu\text{m s}^{-1}$</i>	<i>internal volume of the xylem section / μm^3</i>	<i>environmental factor that could have resulted in change in velocity later in the day</i>
A	0.001	180π	increased sunlight
B	0.001	720π	increased humidity
C	0.001	$1\,800\,000\pi$	increased humidity
D	1000	180π	increased wind speed
E	1000	$1\,800\,000\pi$	increased sunlight
F	1000	$7\,200\,000\pi$	increased humidity
G	3 600 000	720π	increased wind speed
H	3 600 000	$7\,200\,000\pi$	increased sunlight

50 Water in a particular plant moves from a high water potential to a low (more negative) water potential. Water potential is measured in MPa.

Which row correctly describes the most direct pathway for water movement into, through, and out of this plant?

	<i>water potential in soil / MPa</i>	<i>water potential in plant root / MPa</i>	<i>tissue in plant for water transport</i>	<i>water potential in leaf / MPa</i>	<i>water potential in atmosphere / MPa</i>	<i>a mechanism for water leaving the leaf</i>
A	-75	-1.5	xylem	-0.1	-0.033	diffusion
B	-0.033	-0.1	xylem	-1.5	-75	diffusion
C	-0.033	-0.1	phloem	-1.5	-75	diffusion
D	-75	-1.5	phloem	-0.1	-0.033	osmosis
E	-1.5	-75	phloem	-0.033	-0.1	osmosis
F	-0.033	-0.1	xylem	-1.5	-75	osmosis

27 The diagram shows apparatus that can be used to measure the water loss from a leafy shoot.



Three students, P, Q and R, each set up the apparatus and recorded how far the air bubble had moved in 15 minutes. It was observed that each student's apparatus had capillary tubing with a different internal diameter.

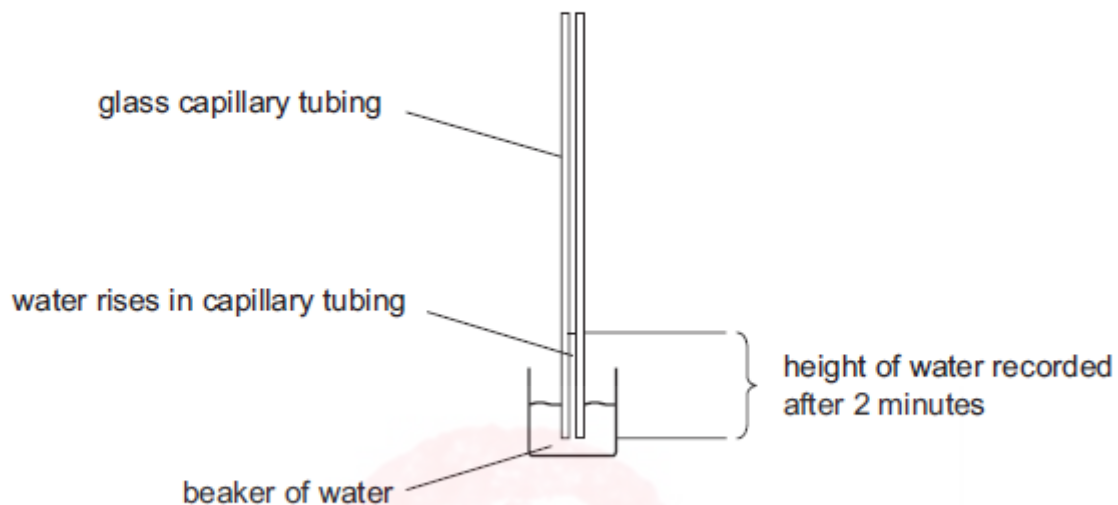
student	distance bubble moved in 15 minutes / mm	internal diameter / mm
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	water lost from most to least	conclusion
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E	R Q P	the apparatus in R was placed in a humid environment
F	R Q P	there is insufficient information to explain the results
G	R P Q	the apparatus in R was placed in a hot dry environment
H	R P Q	there is insufficient information to explain the results

- 51** An experiment was performed to investigate whether capillary action could account for the movement of water from roots to leaves in a plant.

The diagram shows apparatus used to model this effect using narrow glass capillary tubing. The inner diameter of the capillary tubing is 0.5 mm.



The initial height of the water in the tubing was recorded as 0.2 cm. After 2 minutes the height was recorded as 1.8 cm.

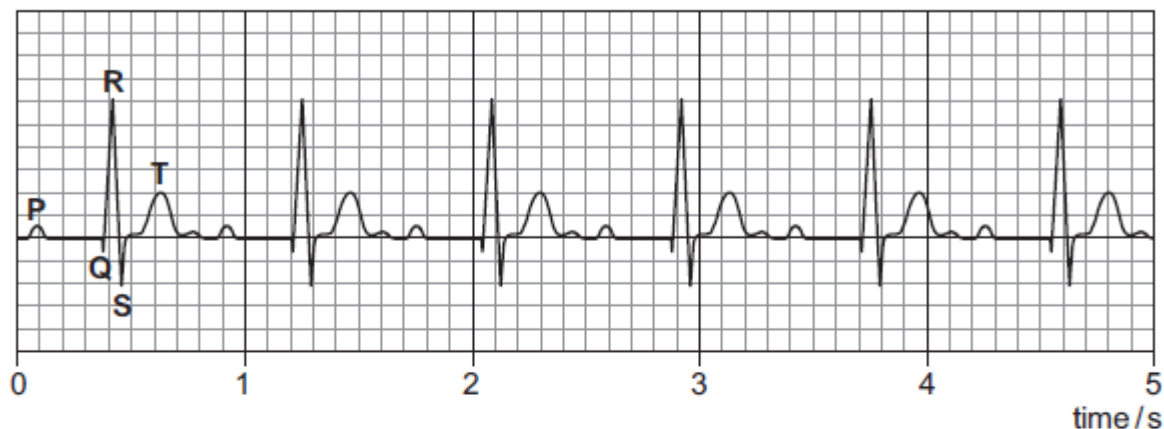
The model assumes the rate of movement is constant.

What is the rate of water movement in $\text{mm}^3 \text{min}^{-1}$ and what vessel type transfers water from roots to leaves in a real plant?

	rate of water movement / $\text{mm}^3 \text{min}^{-1}$	vessel type
A	0.5π	xylem
B	0.5π	phloem
C	π	xylem
D	π	phloem
E	2π	xylem
F	2π	phloem
G	4π	xylem
H	4π	phloem

- 22** The ECG trace shows a recording of the electrical activity of the heart from a person who has a known cardiac condition.

The volume of blood pumped from the ventricles with each contraction was 70 cm^3 .



Which of the following statements is/are correct?

- 1 Cardiac output is 420 cm^3 per minute.
 - 2 There is an abnormal delay in conduction between the sinoatrial node (SAN) and the atrioventricular node (AVN).
 - 3 P indicates atrial diastole.
- A none of them
- B 1 only
- C 2 only
- D 3 only
- E 1 and 2 only
- F 1 and 3 only
- G 2 and 3 only
- H 1, 2 and 3

42 A sample of blood was taken from a healthy human.

There were 5×10^9 red blood cells in 1 cm^3 of the blood.

The ratio of the volume of red blood cells to other blood components was 2 : 3.

Which of the following statements is/are correct?

- 1 The genetic material of a mature red blood cell is contained in its nucleus.
- 2 The mean volume of a red blood cell is $8 \times 10^{-8} \text{ mm}^3$.
- 3 Human red blood cells have a higher surface area to volume ratio compared to a spherical cell of the same volume.

- A none of them
- B 1 only
- C 2 only
- D 3 only
- E 1 and 2 only
- F 1 and 3 only
- G 2 and 3 only
- H 1, 2 and 3



- 47** At a certain time, the percentage of oxygen carried in the blood entering the right atrium is 40% of its maximum capacity.

At this time, a section of a human pulmonary artery is 5 cm long and has a lumen diameter of 2.8 mm.

Another artery in the human body is the renal artery.

What is the volume of blood in this pulmonary artery section, and the oxygen level in the blood in the renal artery, at this time?

	<i>volume of blood in the lumen of this pulmonary artery section / mm³</i>	<i>percentage of oxygen carried in the blood in the renal artery</i>
A	$5 \times (0.14)^2 \times \pi$	less than 40%
B	$50 \times (1.4)^2 \times \pi$	less than 40%
C	$2.8 \times (25)^2 \times \pi$	less than 40%
D	$5 \times (0.14)^2 \times \pi$	40%
E	$50 \times (1.4)^2 \times \pi$	40%
F	$5 \times (0.14)^2 \times \pi$	greater than 40%
G	$50 \times (1.4)^2 \times \pi$	greater than 40%
H	$2.8 \times (25)^2 \times \pi$	greater than 40%

- 48** A 1 cm^3 sample of blood was taken from an infected patient. This sample was added to saline solution to make a total volume of 50 cm^3 .

This diluted sample was then viewed using a haemocytometer, a special microscope slide that allows the number of blood cells in a known volume to be counted. The volume analysed using the haemocytometer was $1.0 \times 10^{-4} \text{ cm}^3$.

The type and number of cells counted is shown.

<i>cell type</i>	<i>number of cells</i>
mature red blood cell	12
white blood cell	4
bacterial cell	5

Using this data only, how many cells with nuclei were present in the 1 cm^3 sample from the patient?

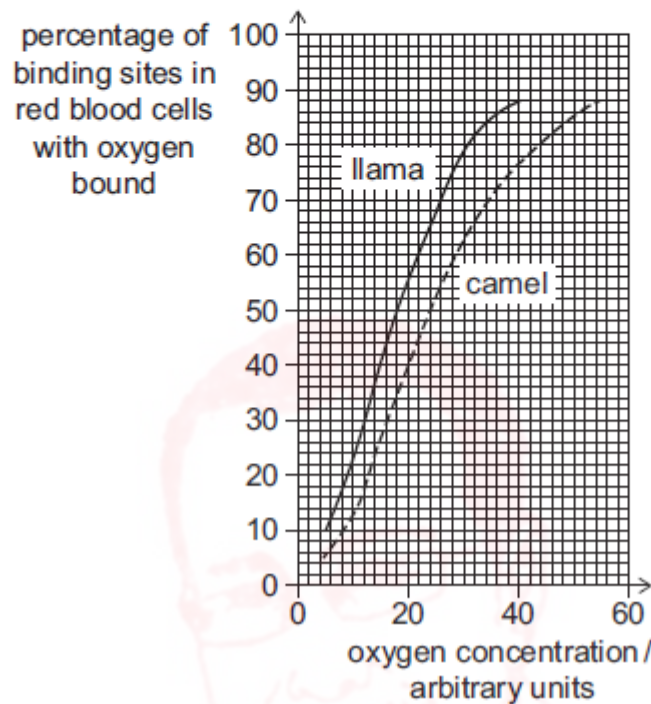
- A 4.0×10^4
- B 9.0×10^4
- C 1.6×10^5
- D 2.0×10^6
- E 4.5×10^6
- F 6.0×10^6
- G 8.0×10^6
- H 1.05×10^7



- 49** The oxygen saturation of red blood cells is the percentage of haemoglobin binding sites in red blood cells with oxygen bound to them.

Camels and llamas have evolved from the same ancestor. Camels live at low altitude and llamas live at high altitude.

The graph shows the effect of oxygen concentration on the oxygen saturation of red blood cells in camels and llamas.



Which of the following statements is/are correct?

- 1 The difference in oxygen binding properties of the red blood cells of camels and llamas is an example of different phenotypes.
- 2 The different oxygen binding properties evolved because of mutations caused by different oxygen concentrations.
- 3 50% oxygen saturation of llama red blood cells occurs at $\frac{3}{4}$ of the oxygen concentration required for 50% oxygen saturation of camel red blood cells.

- A** none of them
- B** 1 only
- C** 2 only
- D** 3 only
- E** 1 and 2 only
- F** 1 and 3 only
- G** 2 and 3 only
- H** 1, 2 and 3

42 The average healthy mature red blood cell contains 200 000 000 molecules of haemoglobin.

If a red blood cell is saturated with dissolved oxygen, each haemoglobin molecule carries a total of 4 molecules of oxygen.

Haemoglobin molecules in red blood cells in the pulmonary artery are on average 65% saturated with oxygen.

How many oxygen molecules are carried by the average red blood cell in the pulmonary artery, and is the level of oxygen saturation greater in the aorta or the pulmonary artery?

	<i>number of oxygen molecules carried</i>	<i>level of oxygen saturation</i>
A	8.0×10^8	aorta > pulmonary artery
B	8.0×10^8	aorta < pulmonary artery
C	5.2×10^8	aorta > pulmonary artery
D	5.2×10^8	aorta < pulmonary artery
E	2.8×10^8	aorta > pulmonary artery
F	2.8×10^8	aorta < pulmonary artery
G	1.3×10^8	aorta > pulmonary artery
H	1.3×10^8	aorta < pulmonary artery



- f) Discuss how the size of organisms affects their ease of exchange of substances with the external environment. You should highlight at least two adaptations that help overcome the constraints of size. [12 marks]

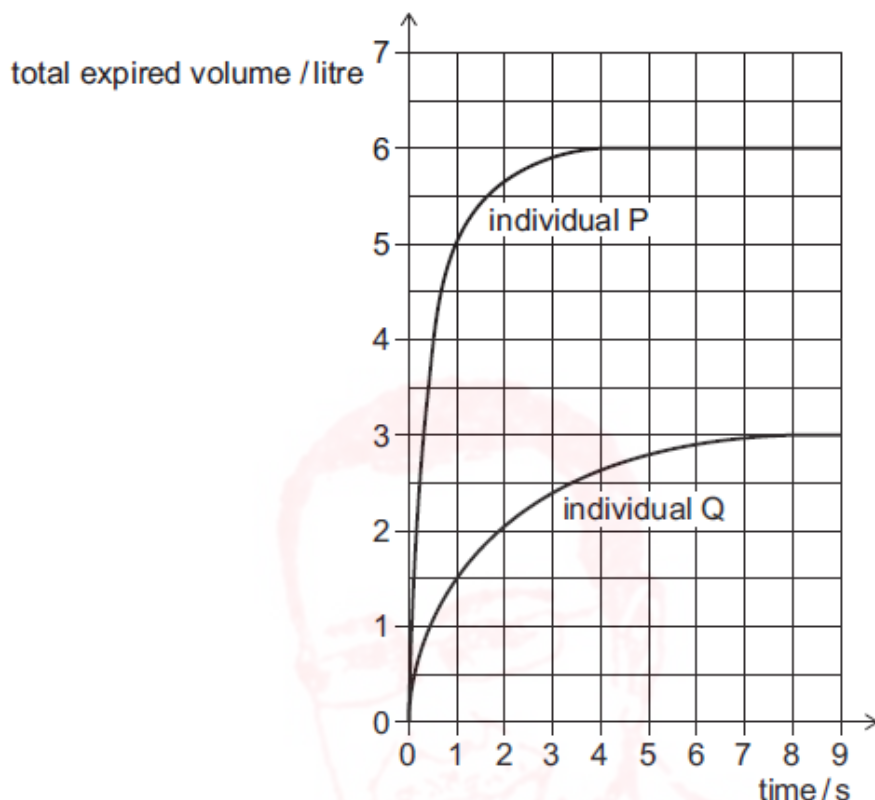
Answer:

.....



- 45** In a test to compare the function of the human respiratory system in different individuals, they were asked to breathe out as hard as possible for as long as possible. The volume exhaled was recorded.

The graph shows the results obtained after carrying out this test on two males with the same height and body mass.



Which of the following statements is/are correct?

- 1 Individual P exhaled 200% more than individual Q.
- 2 Individual Q's diaphragm was more domed at 7 seconds than at 2 seconds.
- 3 The mean rate of air flow in the first second was 233% more in individual P than in individual Q (to the nearest whole percentage).

- A none of them
- B 1 only
- C 2 only
- D 3 only
- E 1 and 2 only
- F 1 and 3 only
- G 2 and 3 only
- H 1, 2 and 3

- 49** In the disease emphysema the walls of the alveoli break down so that several smaller alveoli fuse to form a single large alveolus.

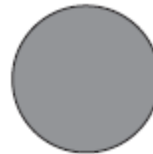
The diagram shows a model of the effect of emphysema on spherical alveoli.

radius of each alveolus = x



4 healthy alveoli

radius of alveolus = $2x$



1 alveolus from a person with emphysema

Which of the following statements is/are correct?

- 1 The surface area-to-volume ratio of the four healthy alveoli is twice that of the single emphysema alveolus.
- 2 For the same concentration gradient, the rate of diffusion of oxygen into the blood from a single healthy alveolus will be greater than for a single emphysema alveolus.
- 3 Oxygen molecules will only move across the alveolus wall from the inside to the outside of an alveolus.

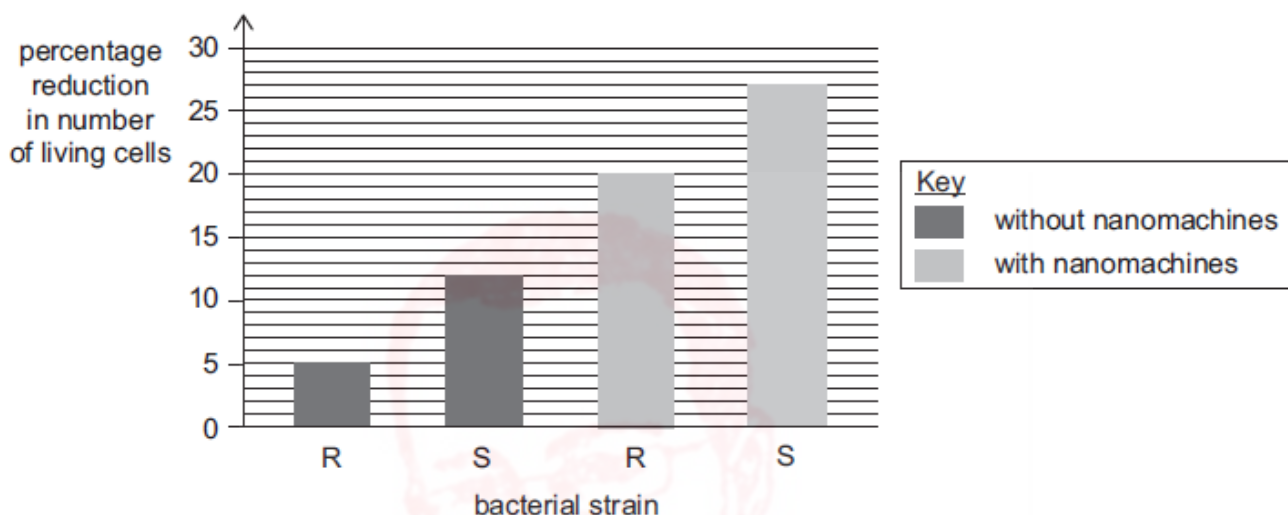
(surface area of a sphere = $4\pi r^2$; volume of a sphere = $\frac{4}{3}\pi r^3$, where r is the radius)

- A none of them
- B 1 only
- C 2 only
- D 3 only
- E 1 and 2 only
- F 1 and 3 only
- G 2 and 3 only
- H 1, 2 and 3

- 50** Some bacteria become resistant to antibiotics due to the loss of the proteins in their cell surface membranes that the antibiotic uses to enter the cell. To overcome this problem, scientists have developed nanomachines that can make holes in these membranes, allowing the antibiotic to enter and destroy the bacteria.

Scientists studied the effects of these nanomachines in two antibiotic-resistant strains of bacteria, R and S. Each culture started with 2.5×10^6 living cells. They carried out two sets of experiments, one without the nanomachines and one with the nanomachines. The results are shown in the chart.

All other factors were kept the same.



Which of the following statements is/are correct?

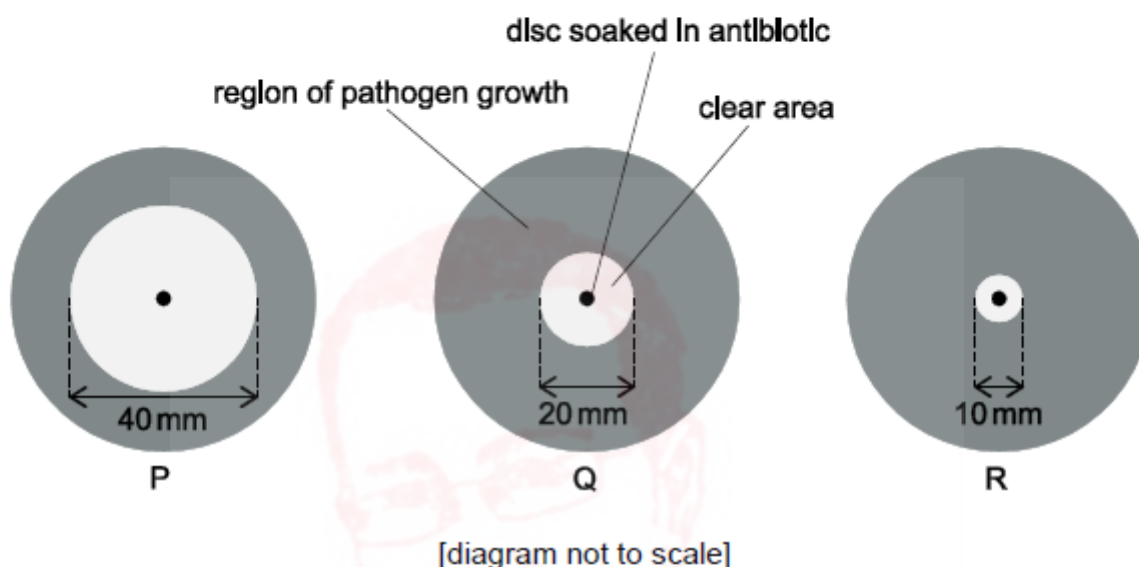
- 1 The number of living cells of strain S in the experiment with the nanomachines is 2.25 times higher than in the experiment without the nanomachines.
 - 2 The cells of strain S may have more proteins in their cell membranes than strain R, which allow the antibiotic to enter their cells.
 - 3 There would be 2×10^6 living cells of strain R at the end of the experiment with the nanomachines.
- A** none of them
- B** 1 only
- C** 2 only
- D** 3 only
- E** 1 and 2 only
- F** 1 and 3 only
- G** 2 and 3 only
- H** 1, 2 and 3

24 A scientist investigates the effects of three antibiotics on the reproduction of a pathogen.

The scientist spreads an equal amount of a culture of the pathogen uniformly across three 10 cm diameter agar plates P, Q and R. Three small discs of filter paper were each soaked in a different antibiotic solution, each of the same concentration. A single disc was then placed into the middle of each agar plate. The plates were then incubated at 30 °C for 24 hours to allow the pathogen to grow.

All other variables were kept constant.

The diagram shows the appearance of the plates after 24 hours incubation.

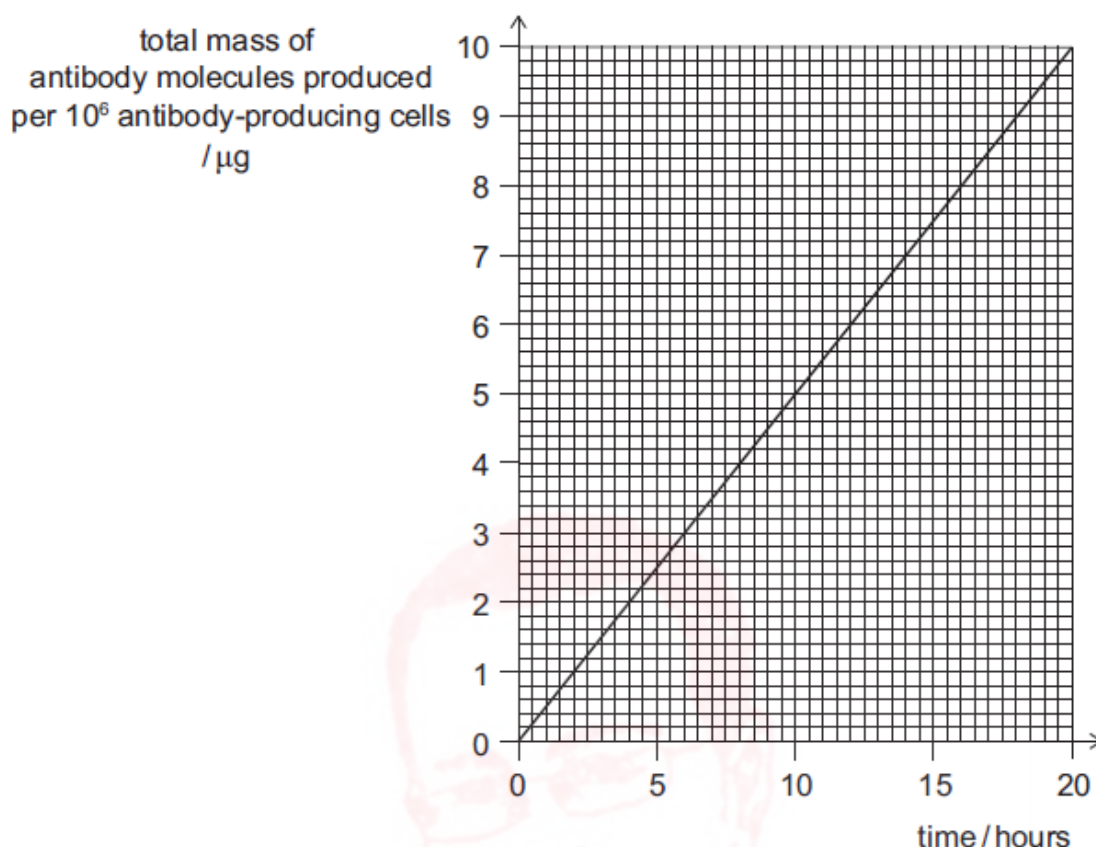


The scientist measured the diameter of the clear area and calculated the area of the pathogen on the plate.

What is the area covered by the pathogen on plate Q, and what is the most effective antibiotic?

	area of the pathogen on plate Q / mm ²	plate with most effective antibiotic
A	100 π	P
B	100 π	R
C	2100 π	P
D	2100 π	R
E	2400 π	P
F	2400 π	R
G	9600 π	P
H	9600 π	R

- 46** The graph shows the mass of antibody produced by antibody-producing cells over a period of 20 hours.



Assume that one antibody molecule has a mass of $2.5 \times 10^{-19} \text{ g}$.

Which of the following statements is/are correct?

- 1 One antibody-producing cell produces 2×10^6 antibody molecules per hour.
- 2 Antibodies are produced in response to dead and living pathogens.
- 3 Phagocytes produce antibodies.

- A none of them
- B 1 only
- C 2 only
- D 3 only
- E 1 and 2 only
- F 1 and 3 only
- G 2 and 3 only
- H 1, 2 and 3

21 How a non-lethal communicable disease spreads through a population can be modelled using two factors:

- R_0 , the average number of people who catch the disease from one infected person
- the proportion of the population who are immune either naturally or by vaccination

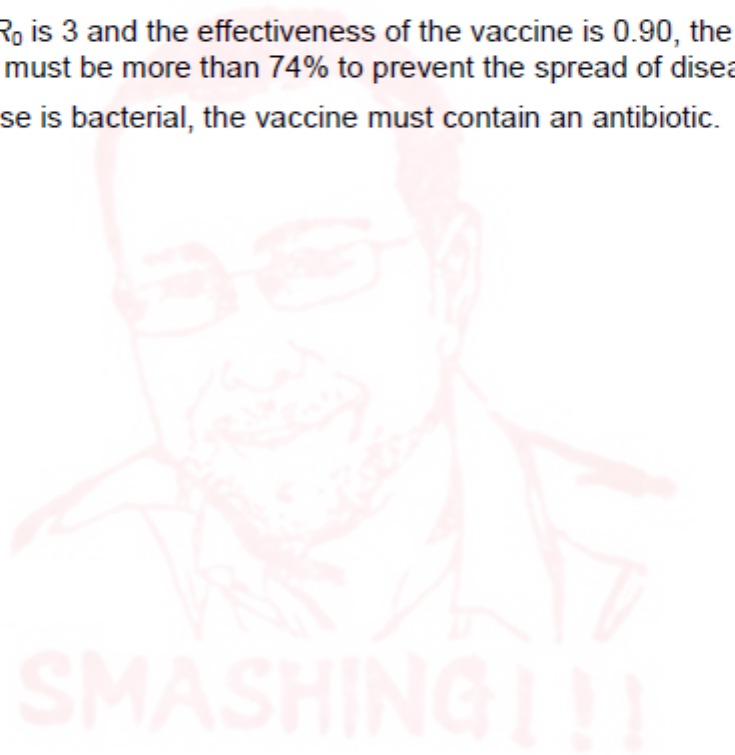
As vaccines are not always effective, the percentage of people in a population who must be vaccinated to prevent the spread of the disease can be calculated by:

$$\left(\frac{1 - \frac{1}{R_0}}{\text{effectiveness of the vaccine}} \right) \times 100$$

Which of the following statements is/are correct?

- 1 If the effectiveness of the vaccine remains the same, an increase in R_0 increases the number of people who need to be vaccinated to prevent the spread of disease.
- 2 When the R_0 is 3 and the effectiveness of the vaccine is 0.90, the percentage to be vaccinated must be more than 74% to prevent the spread of disease.
- 3 If the disease is bacterial, the vaccine must contain an antibiotic.

- A none of them
- B 1 only
- C 2 only
- D 3 only
- E 1 and 2 only
- F 1 and 3 only
- G 2 and 3 only
- H 1, 2 and 3



- 46** The average volume of a mammalian mitochondrion is $0.5 \mu\text{m}^3$. The density of the enzymes within the mitochondria is 450 mg of enzymes per mm^3 of mitochondrial volume.

What is the mass, in mg, of enzyme inside an average mammalian mitochondrion, and how would a decrease in enzyme density within all mitochondria inside a cell change the rate of anaerobic respiration in the cell as a whole?

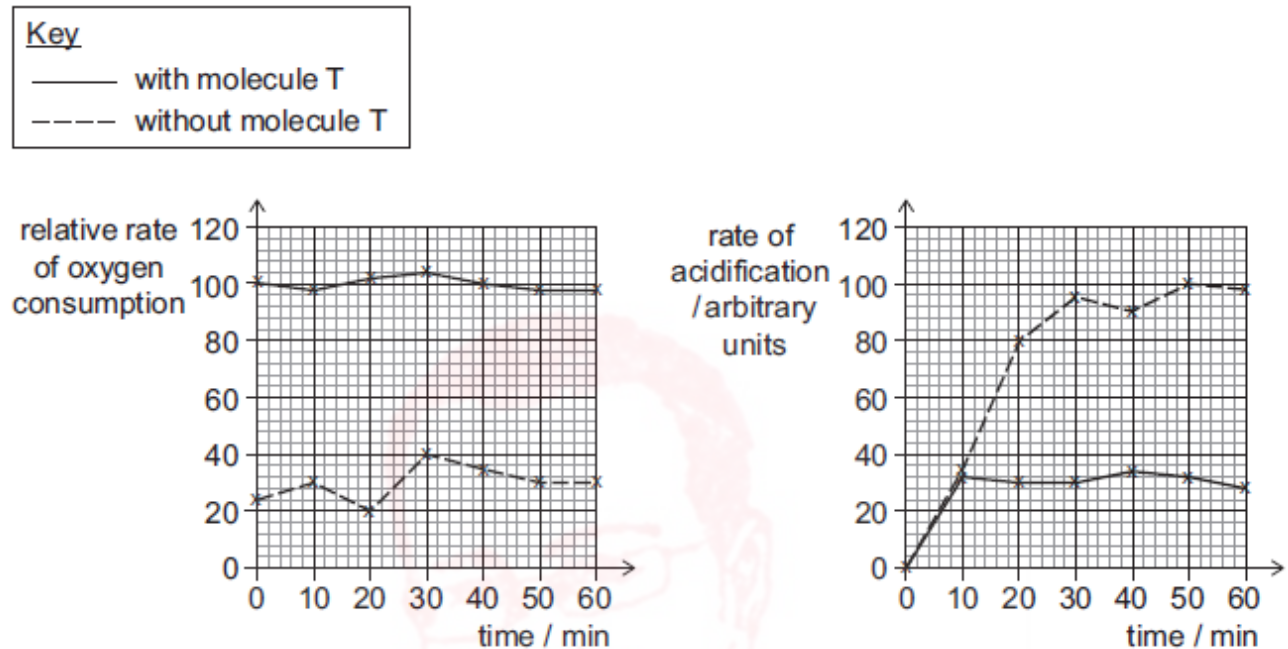
(Assume that the overall metabolic rate of the cell remains constant.)

	<i>mass of enzyme inside an average mammalian mitochondrion / mg</i>	<i>change in the rate of anaerobic respiration in the cell as a whole that may occur if the enzyme density decreases</i>
A	2.25×10^{-7}	decreases
B	2.25×10^{-7}	increases
C	2.25×10^{-3}	decreases
D	2.25×10^{-3}	increases
E	2.25×10^{-1}	decreases
F	2.25×10^{-1}	increases
G	2.25×10^2	decreases
H	2.25×10^2	increases

- 56** Mutations can occur in the genes coding for some of the enzymes that catalyse respiration reactions. This can result in mitochondria that do not function correctly.

Scientists studying this tested a molecule, T, for its ability to restore the function to these mitochondria in human cells.

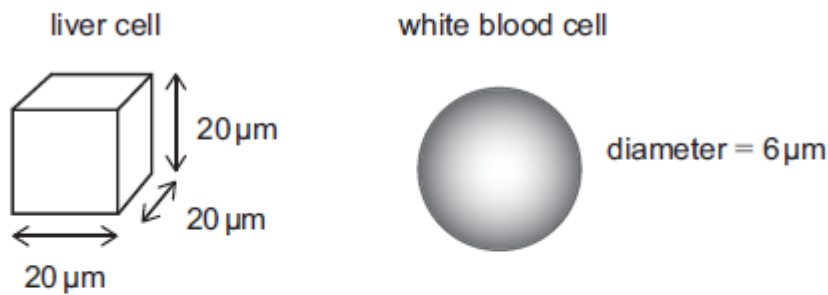
The graphs show the rate of oxygen consumption, measured relative to the percentage of healthy mitochondria, and the rate of acidification of the cellular environment, over time.



Which of the following statements is/are correct?

- 1 Molecule T could reduce the rate of lactic acid production in the cells.
 - 2 Between 20 and 30 minutes, the oxygen consumption rate without molecule T increases by 50%.
 - 3 The concentration gradient for oxygen between the cell cytoplasm and the mitochondria is steeper with molecule T compared to without molecule T.
- A** none of them
- B** 1 only
- C** 2 only
- D** 3 only
- E** 1 and 2 only
- F** 1 and 3 only
- G** 2 and 3 only
- H** 1, 2 and 3

- 52** Two healthy human cells with no mutations were modelled as shown in the diagrams below. The cells were not dividing. Both cells contain a single nucleus and are diploid.



[diagram not to scale]

A study estimates that mitochondria account for 12% of the volume of both types of cells.

Using this estimate for all cells, which of the following is/are correct?

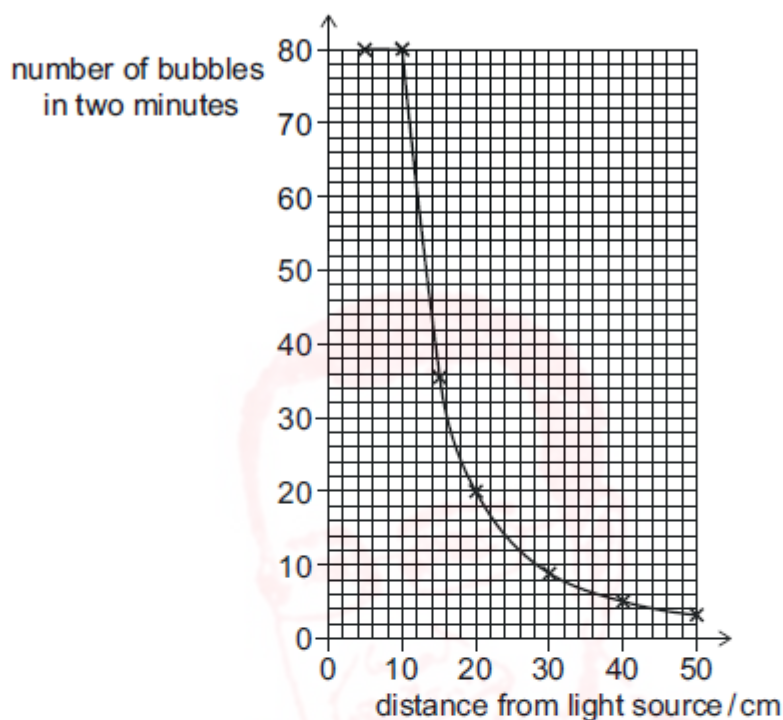
(The volume of a sphere is given by $\frac{4}{3}\pi r^3$, where r is the radius. Use the value 3.14 for π)

- 1 The larger number of mitochondria in the liver cell will produce more lactic acid than those in the white blood cell.
 - 2 The liver cell is larger and so will contain a greater mass of nuclear DNA than the white blood cell.
 - 3 The mitochondria in the white blood cell occupy $14\ \mu\text{m}^3$ to the nearest whole number.
- A none of them
B 1 only
C 2 only
D 3 only
E 1 and 2 only
F 1 and 3 only
G 2 and 3 only
H 1, 2 and 3

- 29** Pondweed, in a solution of sodium hydrogen carbonate, was placed in front of a light source to investigate the relationship between light intensity and the rate of photosynthesis. The number of bubbles of gas produced during a period of two minutes was recorded. The experiment was repeated with the light source at different distances from the pondweed.

The relationship between light intensity and distance (d) from a light source can be described

as: light intensity $\propto \frac{1}{d^2}$



Which of the following statements is/are correct?

- 1 The bubbles produced were composed mostly of carbon dioxide.
 - 2 Between 10 cm and 50 cm the rate of photosynthesis is directly proportional to light intensity.
 - 3 At a distance of 5 cm from the pondweed, light intensity was the limiting factor for photosynthesis.
- A none of them
- B 1 only
- C 2 only
- D 3 only
- E 1 and 2 only
- F 1 and 3 only
- G 2 and 3 only
- H 1, 2 and 3

- 44** A student studied the effect of different colours of light on photosynthesis by algae. Large numbers of algal cells were trapped inside balls of a clear jelly-like substance. The average diameter of the algal balls was 5 mm.

These balls were then placed in a test tube filled with a solution. The solution contained substances necessary for photosynthesis by the algal cells, and had a pH of 7.8. The whole test tube was then wrapped in a coloured filter and left in bright light for two hours. All other factors were kept constant.

After two hours the pH of each solution was measured. The results are shown in the table.

<i>colour of filter</i>	<i>pH of solution after two hours</i>
blue	8.3
green	7.5
red	8.6
colourless	9.3
black	7.1

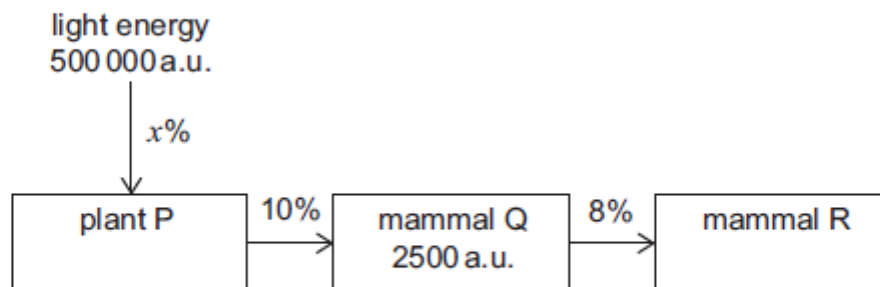
The volume of a sphere is $\frac{4}{3}\pi r^3$, where r is the radius.

Which of the following statements is/are correct?

- 1 The average volume of one of the algal balls is $\frac{1}{6}\pi \text{ cm}^3$.
- 2 In only the test tubes with red, blue and colourless filters, the increase in pH can be explained by an increase in the amount of carbon dioxide released by the algal balls.
- 3 Conducting these experiments at a higher temperature could increase the rate of change in pH in all the tubes.

- A none of them
- B 1 only
- C 2 only
- D 3 only
- E 1 and 2 only
- F 1 and 3 only
- G 2 and 3 only
- H 1, 2 and 3

- 42** The diagram shows a food chain. The numbers represent energy available and are in arbitrary units (a.u.), and the percentages represent efficiency of energy transfer.



The energy transfer between trophic levels is not 100% efficient.

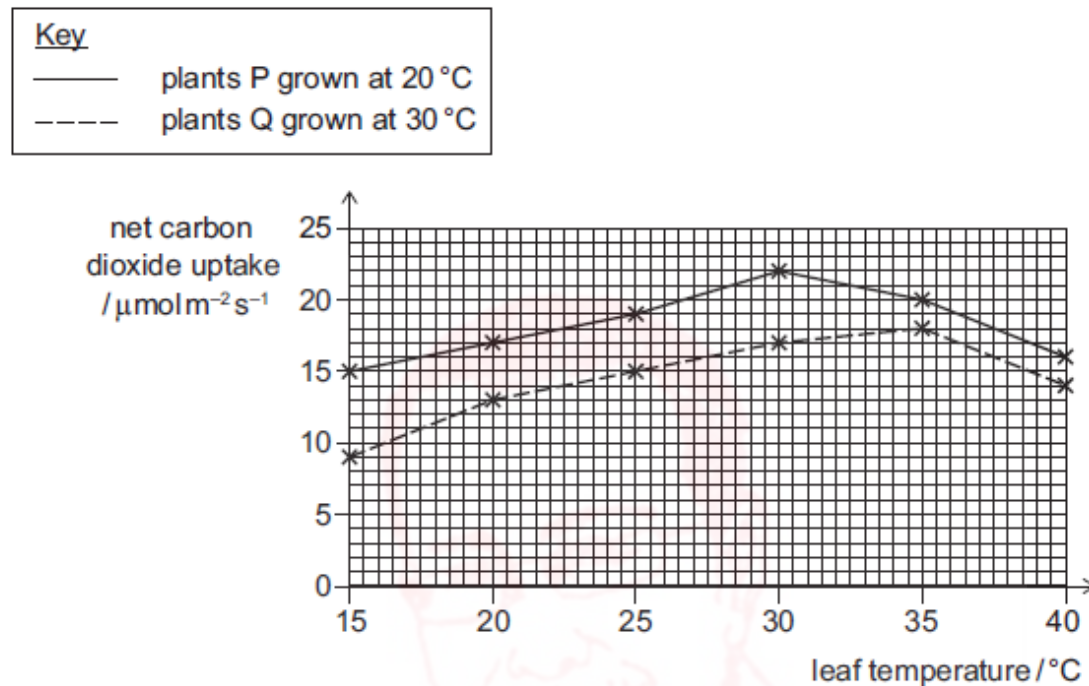
Which row is correct for this food chain?

	<i>efficiency of energy transfer x</i>	<i>a reason for inefficiency of energy transfer from Q to R</i>
A	1%	energy lost as heat
B	1%	cellulose not digested
C	1%	some wavelengths of light not used
D	5%	energy lost as heat
E	5%	cellulose not digested
F	5%	some wavelengths of light not used

- 44** A scientist studied one species of plant and grew some at 20 °C (plants P) and some at 30 °C (plants Q). All other variables were kept constant.

The scientist then placed plants from each group into six separate temperature-controlled cabinets, each at a different temperature. The plants were left for 15 minutes to adjust to their new temperature. The scientist then measured the rate of net carbon dioxide uptake by the leaves on the plants. All other variables were kept constant.

The results are shown in the graph.

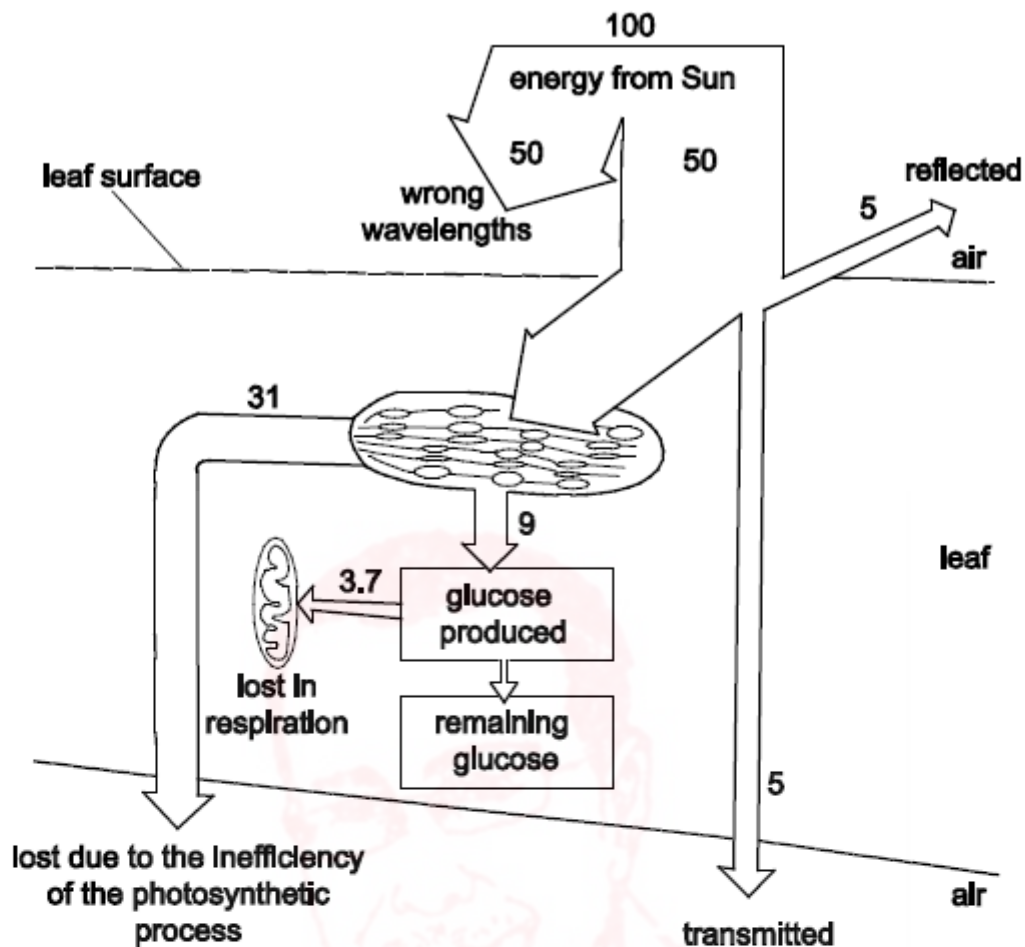


Which of the following statements is/are correct?

- 1** At 35 °C, a 200 cm² leaf of plant P would take up 1.44×10^7 μmol of carbon dioxide in one hour.
- 2** Assuming that their respiration rates are the same, the rate of oxygen production in a leaf from plant P at 20 °C will be approximately equal to that in a leaf of the same size from plant Q at 30 °C.
- 3** The optimum temperature for maximum rate of photosynthesis in plant P must be 30 °C.

- A** none of them
- B** 1 only
- C** 2 only
- D** 3 only
- E** 1 and 2 only
- F** 1 and 3 only
- G** 2 and 3 only
- H** 1, 2 and 3

25 The diagram represents a simplified model of a leaf processing solar energy. 100 units of solar energy reach the surface of the leaf.



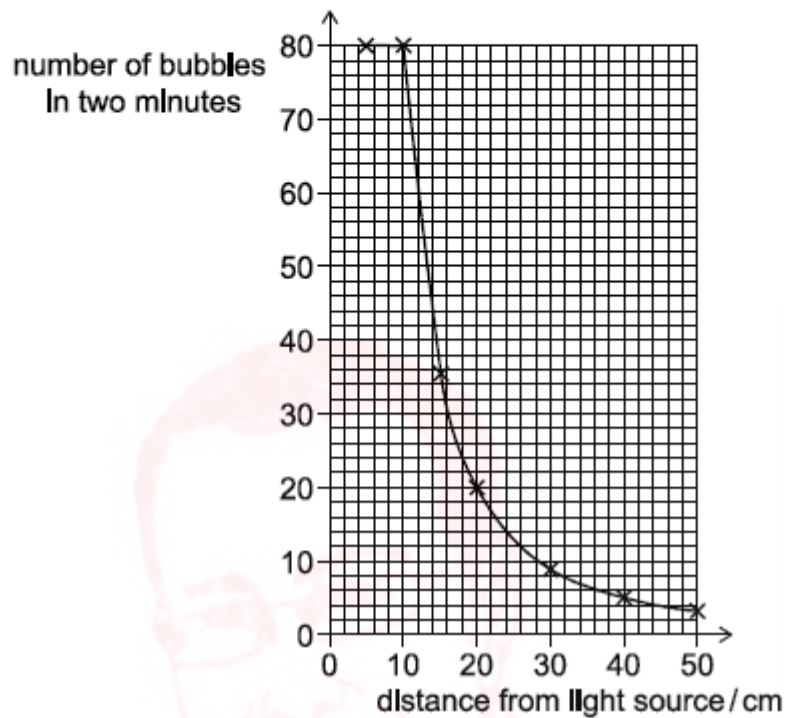
Which of the following statements is/are correct?

- 1 60% of the solar energy reaching the leaf is not absorbed by the chloroplasts.
- 2 22.5% of the energy absorbed by the chloroplasts is used to form glucose.
- 3 A maximum of 5.3 units of solar energy becomes energy available to the primary consumer.

- A none of them
- B 1 only
- C 2 only
- D 3 only
- E 1 and 2 only
- F 1 and 3 only
- G 2 and 3 only
- H 1, 2 and 3

- 29** Pondweed, in a solution of sodium hydrogen carbonate, was placed in front of a light source to investigate the relationship between light intensity and the rate of photosynthesis. The number of bubbles of gas produced during a period of two minutes was recorded. The experiment was repeated with the light source at different distances from the pondweed.

The relationship between light intensity and distance (d) from a light source can be described as: light intensity $\propto \frac{1}{d^2}$



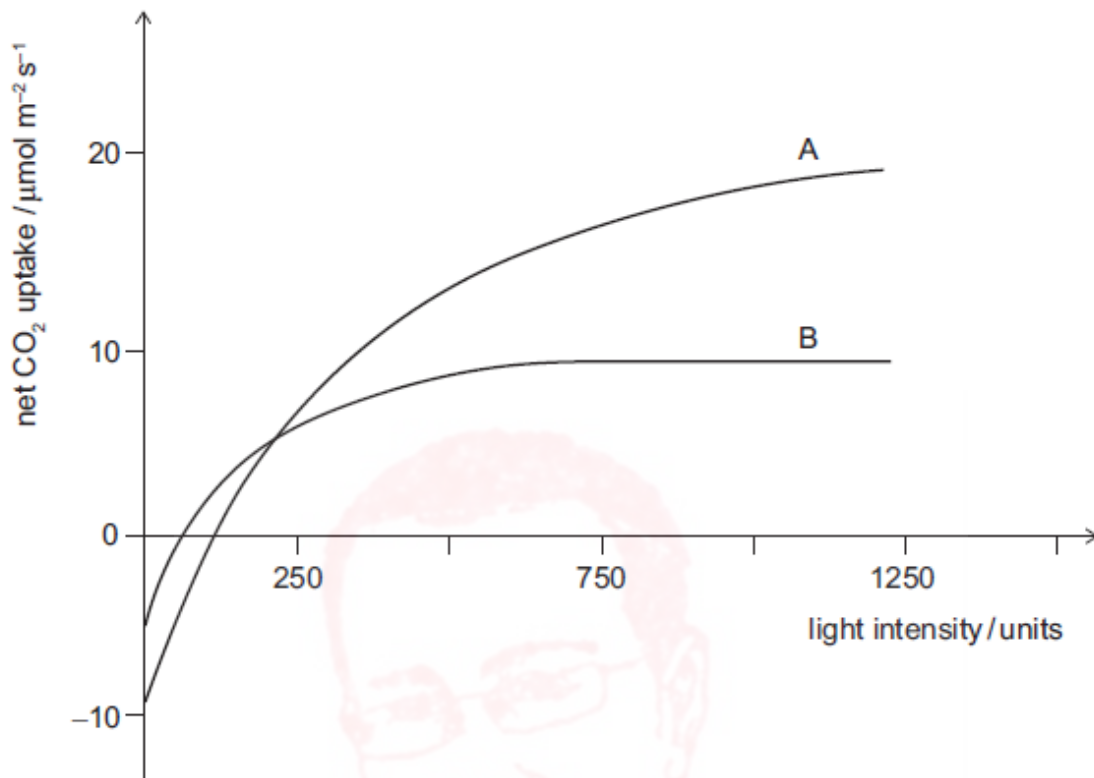
Which of the following statements is/are correct?

- 1 The bubbles produced were composed mostly of carbon dioxide.
- 2 Between 10 cm and 50 cm the rate of photosynthesis is directly proportional to light intensity.
- 3 At a distance of 5 cm from the pondweed, light intensity was the limiting factor for photosynthesis.

- A none of them
- B 1 only
- C 2 only
- D 3 only
- E 1 and 2 only
- F 1 and 3 only
- G 2 and 3 only
- H 1, 2 and 3

Question B2

The graph shows net CO₂ uptake of two different plants, A and B, when exposed to increasing light levels.



a) Name two physiological processes that affect the net CO₂ uptake in plants.

[1 mark]

Answer:

.....

.....

b) State what can be concluded when the net CO₂ uptake in each plant is zero.

[1 mark]

Answer:

.....

.....

- c) For plant B, estimate the value at which increasing light intensity no longer affects CO₂ uptake. [1 mark]

Answer:

.....

- d) Estimate the number of micromoles of CO₂ that would be taken up by a 50 cm² leaf of plant B in one minute at light intensity of 750 units. [2 marks]

Answer:

.....

.....

.....

.....

- e) Propose two explanations for the existence of a plateau in the curve for plant B. [2 marks]

Answer:

.....

.....

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- f) Describe the differences in the curves for plants A and B and suggest why these differences might occur. [3 marks]

Answer:

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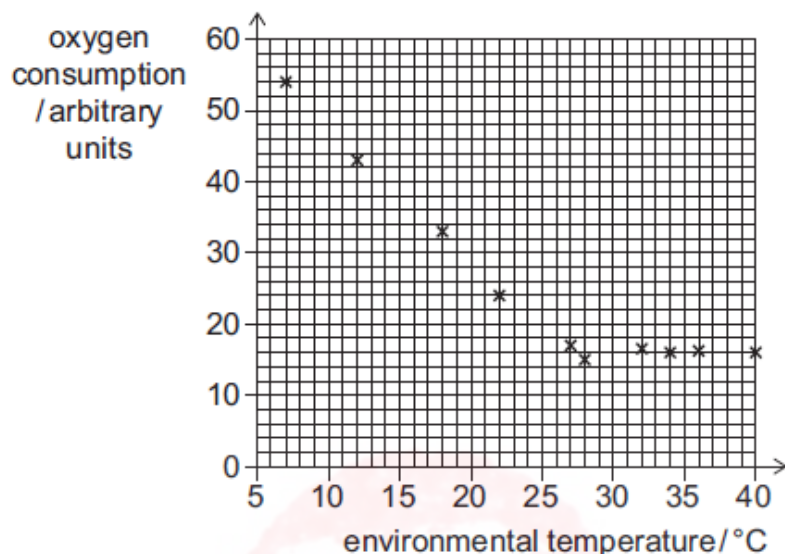
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54 In cold conditions mice maintain their core body temperature by increased heat production.

The graph shows the effect of environmental temperature on oxygen consumption by one strain of mouse.



Mice of the same strain have been produced with a mutation that results in a thinner and less insulating layer of fat in their skin.

Which of the following statements is/are correct?

- 1 The homeostatic control of core body temperature only occurs in environmental temperatures between 28 °C and 40 °C.
- 2 Between 12 °C and 18 °C, each 1 °C increase in temperature decreases the mean oxygen consumption by $1\frac{2}{3}$ arbitrary units.
- 3 Between 10 °C and 20 °C, the change in oxygen consumption for the mice with the mutation will decrease more than for the non-mutated mice.

- A** none of them
- B** 1 only
- C** 2 only
- D** 3 only
- E** 1 and 2 only
- F** 1 and 3 only
- G** 2 and 3 only
- H** 1, 2 and 3

55 A scientist studied the aorta, a renal artery and a capillary in a healthy human.

The scientist measured the radii of two of the vessels, P and Q, and made a drawing of the third, R.

- P: lumen radius = $2.5 \times 10^{-3} \text{ m}$
- Q: lumen radius = $8000 \mu\text{m}$
- R: at magnification $\times 5000$, diameter of lumen in drawing = 4.5 cm

Which row identifies the three blood vessels?

	<i>vessel P</i>	<i>vessel Q</i>	<i>vessel R</i>
A	aorta	capillary	renal artery
B	aorta	renal artery	capillary
C	capillary	aorta	renal artery
D	capillary	renal artery	aorta
E	renal artery	aorta	capillary
F	renal artery	capillary	aorta

51 On a cool spring day (day 1), a healthy human produces 1500 cm^3 of urine.

The concentration of urea in the urine was measured as $2.00 \text{ g per } 100 \text{ cm}^3$.

On a similar day (day 2), the same person plays a game of hockey and produces 20% less urine. However, the mass of urea excreted in the urine remains the same.

The volume of urine produced is affected by the movement of water in the nephron.

Which row shows the urea concentration in the urine, in g dm^{-3} , on day 1 and day 2, and the explanation for the change in urine volume?

	urea concentration / g dm^{-3}		explanation for change in urine volume	
	day 1	day 2	change in ADH (vasopressin)	change in water movement in the nephron
A	20.0	16.7	decrease	decrease in secretion of water
B	20.0	16.7	increase	increase in reabsorption of water
C	20.0	25.0	decrease	decrease in secretion of water
D	20.0	25.0	increase	increase in reabsorption of water
E	30.0	25.0	decrease	decrease in secretion of water
F	30.0	25.0	increase	increase in reabsorption of water
G	30.0	36.0	decrease	decrease in secretion of water
H	30.0	36.0	increase	increase in reabsorption of water

55 Samples of solution removed from different positions inside a nephron are analysed.

The rate of flow of the solution through the nephron is measured at each position where the samples are taken.

The rate of flow is the volume of solution passing a particular point per unit time.

In the Bowman's capsule, the concentration of sodium ions is the same as in the blood. The rate of flow is 100 arbitrary units.

At the collecting duct, the concentration of sodium ions is twice that in the blood. The rate of flow is 1 arbitrary unit.

Which row in the table is correct?

	<i>percentage sodium ions reabsorbed in the nephron</i>	<i>a process by which sodium ions can be reabsorbed from the nephron</i>
A	2%	active transport
B	2%	diffusion
C	50%	osmosis
D	50%	diffusion
E	98%	active transport
F	98%	osmosis

47 The table shows the sources of water lost in one particular day from a healthy human.

<i>percentage of the water that is lost</i>	<i>source</i>
16	exhaled air
4	faeces
20	sweat
60	urine

On another day, the percentage of water lost in urine decreased by a sixth.

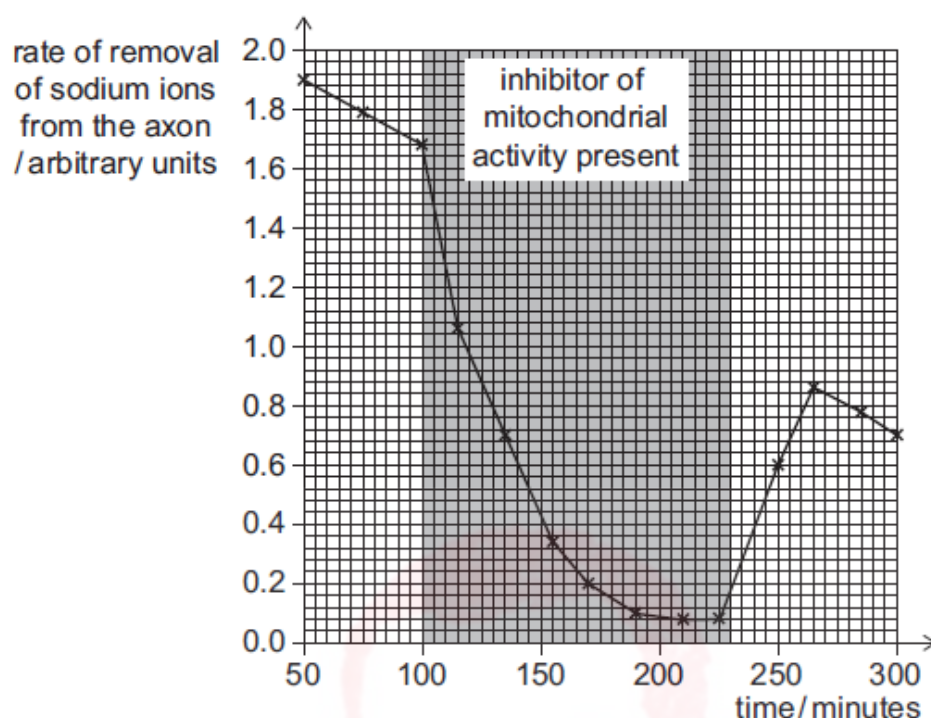
The percentage of water lost in exhaled air and in faeces remained the same.

The total volume of water lost was 2500 cm³ on both days.

What is the percentage increase in the volume of sweat produced and the reason for the decrease in the volume of urine?

	<i>percentage increase in the volume of sweat</i>	<i>reason for the decrease in the volume of urine</i>
A	33	a decrease in ADH
B	33	an increase in ADH
C	50	a decrease in ADH
D	50	an increase in ADH
E	150	a decrease in ADH
F	150	an increase in ADH

- 57 The graph shows the rate of removal of sodium ions from a giant axon in a squid. Between 100 and 230 minutes, a reversible inhibitor of mitochondrial activity was present.



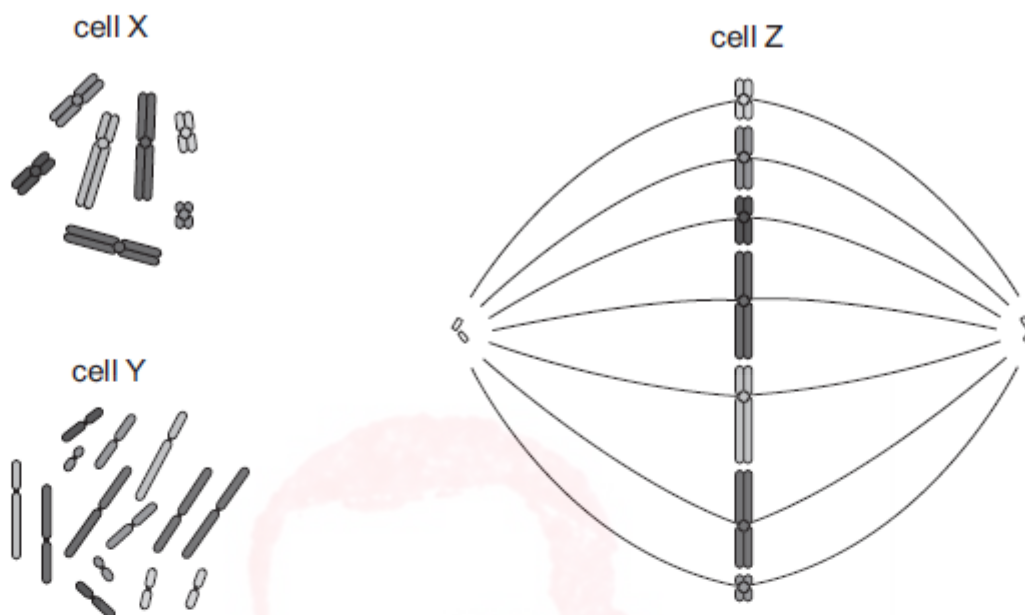
Which of the following statements is/are correct?

- 1 The removal of sodium ions across the cell surface membrane of the axon is an active process requiring ATP.
- 2 The concentration of sodium ions in the axon must increase after the inhibitor has been removed.
- 3 In the 50 minutes before the inhibitor was added, the rate of removal of sodium ions from the axon decreases by 4.4×10^{-3} arbitrary units per minute.

- A none of them
- B 1 only
- C 2 only
- D 3 only
- E 1 and 2 only
- F 1 and 3 only
- G 2 and 3 only
- H 1, 2 and 3

- 25** The Tasmanian devil (*Sarcophilus harrisii*) is a carnivorous mammal with a diploid number of 14.

Three cells were removed from a healthy Tasmanian devil. The chromosomes in each cell were stained and are shown in the following diagram.



Which of the following statements is/are correct?

- 1 Cell X is the first stage of cell division after the end of interphase.
- 2 Cell Y has twice the mass of DNA as cell Z.
- 3 Cell Z is undergoing metaphase of mitosis.

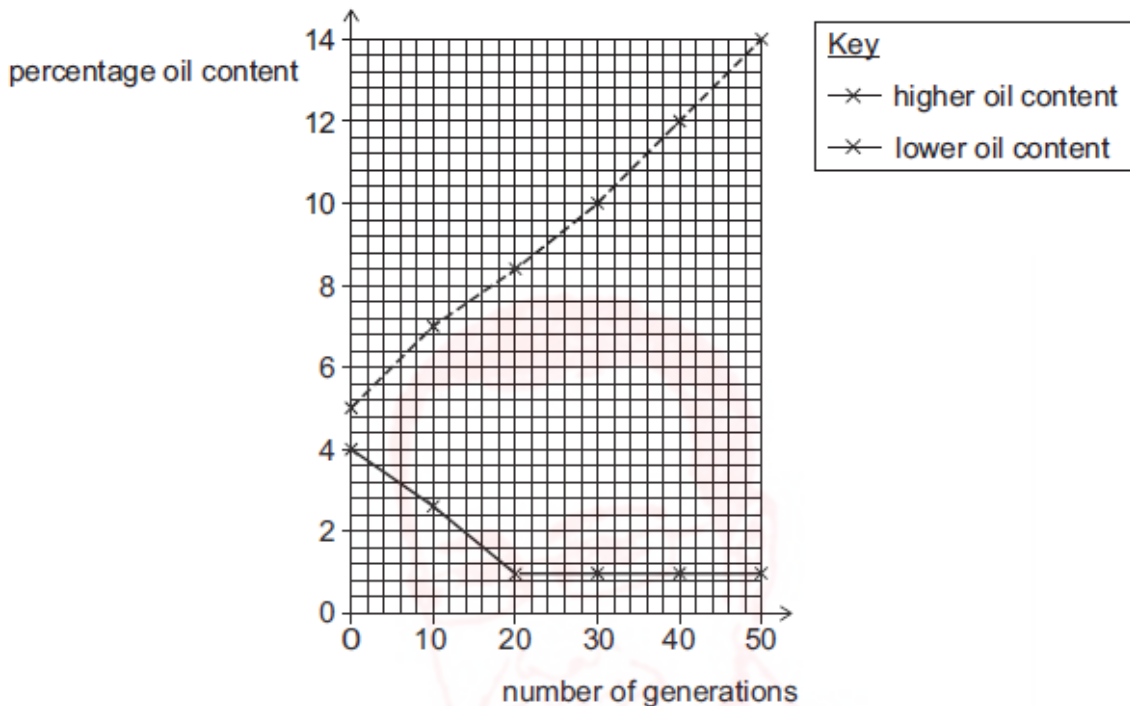
(Assume no mutations.)

- A none of them
- B 1 only
- C 2 only
- D 3 only
- E 1 and 2 only
- F 1 and 3 only
- G 2 and 3 only
- H 1, 2 and 3

28 There is significant variation in the amount of oil present in maize grains.

In an experiment, maize grains were tested for their oil content and only those with either highest or lowest oil content were selected and planted. When this generation of plants matured and produced maize grains, these were tested for their oil content and the selection process was repeated. This was done over fifty generations of maize.

All plants were grown in the same conditions. The mean mass per maize grain was 0.4 g and did not change over the fifty generations. The results are shown in the graph.

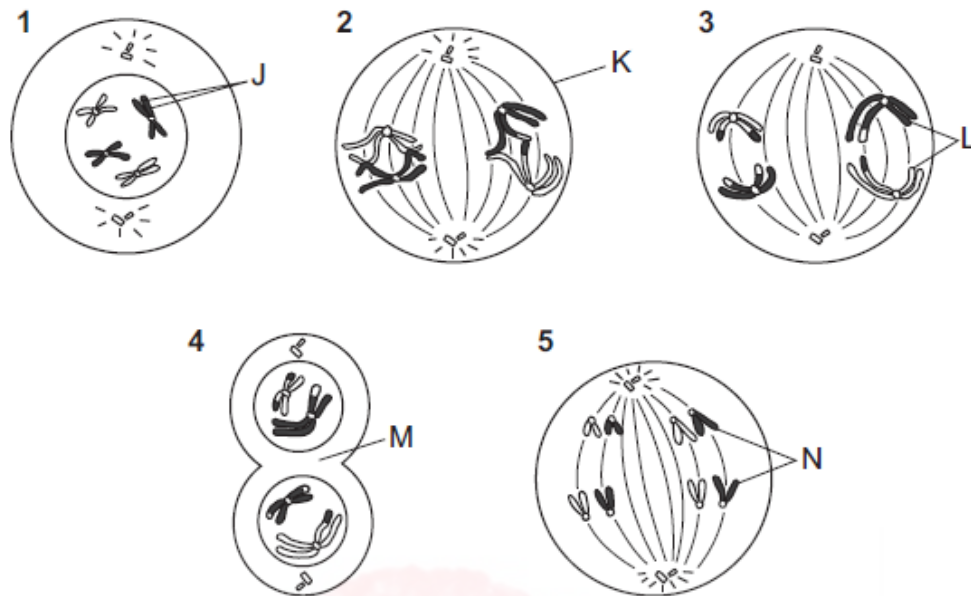


Which of the following statements about the experiment is/are correct?

- 1 The change in oil content over the fifty generations was due to natural selection.
- 2 There was a 180% increase in the oil content of the grains with a higher oil content over the fifty generations.
- 3 The change in mass of oil per grain in the higher oil content grains over the fifty generations was 0.036 g.

- A none of them
- B 1 only
- C 2 only
- D 3 only
- E 1 and 2 only
- F 1 and 3 only
- G 2 and 3 only
- H 1, 2 and 3

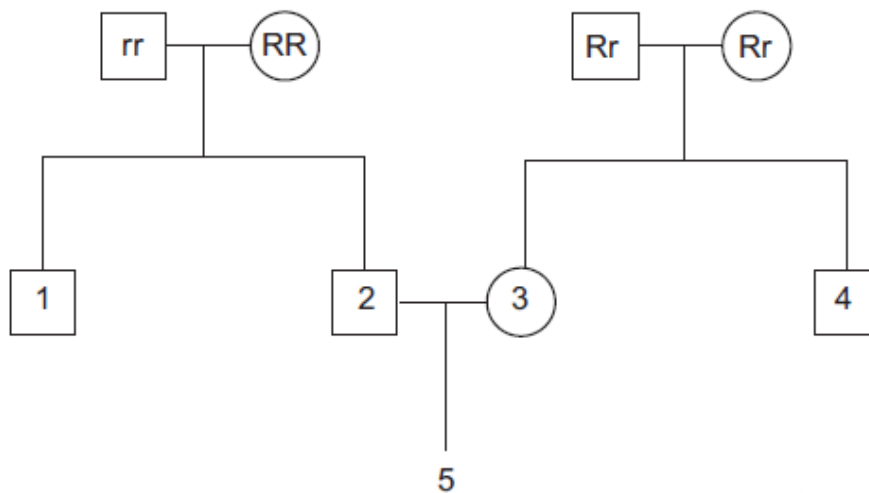
58 The diagrams show some stages of mitosis and meiosis in a healthy human male.



Which row identifies the correct process, the stage of that process, and label?

	<i>diagram number</i>	<i>process</i>	<i>stage</i>	<i>label</i>
A	1	mitosis	prophase	J: paired homologous chromosomes
B	2	meiosis	metaphase 1	K: nuclear membrane of sperm cell
C	3	meiosis	anaphase 2	L: bivalents being separated
D	4	meiosis	telophase 1	M: cleavage of cytoplasm
E	5	mitosis	metaphase	N: sister chromatids

- 59 The family tree shows inheritance of the alleles for one characteristic in a mammal. The gene for this characteristic was found on a non-sex chromosome in the nucleus.



What is the probability that individual 5 is homozygous for the allele R?

- A 0
- B 0.25
- C 0.33
- D 0.5
- E 0.67
- F 0.75
- G 1

- 41** Cystic fibrosis and sickle cell anaemia are both recessive genetic conditions and the genes for these conditions are found on different non-sex chromosomes.

The following statements are true for one set of parents who have only one child:

- Both parents are heterozygous for cystic fibrosis.
- One parent is homozygous recessive for sickle cell anaemia.
- One parent is heterozygous for sickle cell anaemia.

What is the probability of this child having both conditions?

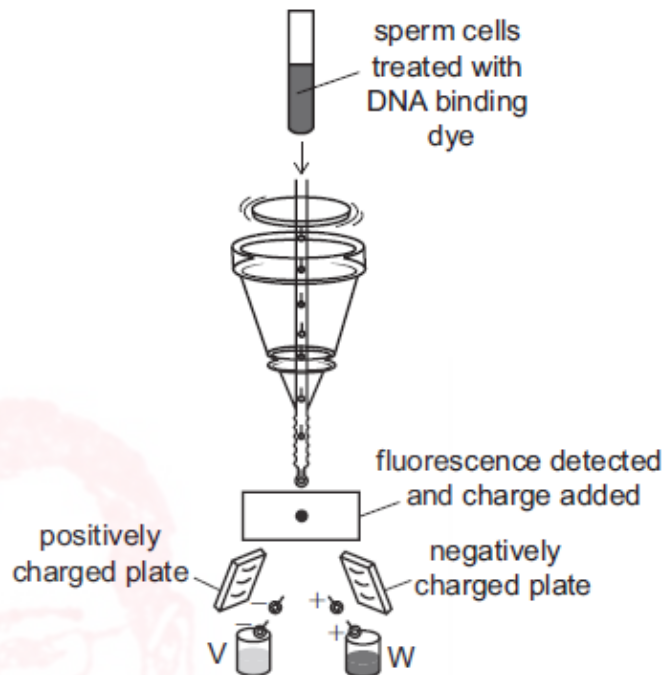
- A** 0.75
- B** 0.5
- C** 0.375
- D** 0.25
- E** 0.125
- F** 0.0625



- 53** Sex determination in cows is identical to that in humans. To maximise productivity, dairy farmers want their cows to have female calves only.

Sperm cells can be sorted using their DNA content. This method is used to ensure the sex of calves born to dairy cows following artificial insemination. The method used is described below:

- The sperm cells are treated with a DNA binding dye.
- The greater the DNA content, the brighter the binding dye fluoresces.
- The brighter sperm cells are given a positive charge and the remaining sperm cells are given a negative charge.
- The charged sperm cells pass through a pair of charged plates and are attracted to the plate with the opposite charge.
- The sperm cells are collected in beakers below the plates.



Assume that all the separated sperm cells are alive and capable of fertilisation, no mutations have occurred, and the method of separation is 100% efficient.

Which of the following statements is/are correct?

- 1 Sperm cells in beaker V have fewer chromosomes.
 - 2 For maximum productivity, dairy farmers should only use positively charged sperm cells.
 - 3 The chance of obtaining a female calf using sperm cells from beaker W will be double that of using unseparated sperm cells.
- A** none of them
- B** 1 only
- C** 2 only
- D** 3 only
- E** 1 and 2 only
- F** 1 and 3 only
- G** 2 and 3 only
- H** 1, 2 and 3

- 54** In a sample of four healthy human cells, three rounds of division occur. After the three divisions, there are a total of 1472 chromosomes present in the sample.

The diploid number in human cells is 46.

Which of the following statements about this sample is/are correct?

- 1** The cells could all be fertilised eggs that divided by mitosis only.
 - 2** The cell divisions could be two rounds of mitosis and then one round of complete meiosis.
 - 3** If a single mutation occurred in one allele just before the second division in one cell, then the final percentage of the cells with this mutation would be 12.5%.
- A** none of them
- B** 1 only
- C** 2 only
- D** 3 only
- E** 1 and 2 only
- F** 1 and 3 only
- G** 2 and 3 only
- H** 1, 2 and 3



- 59** A mathematical test can be used to determine whether there is a statistically significant difference between the expected and the observed number of individuals with each phenotype in a population.

The value required for this test is calculated using the following expression:

$$\frac{(\text{observed} - \text{expected})^2}{\text{expected}} + \dots + \frac{(\text{observed} - \text{expected})^2}{\text{expected}}$$

where each term uses the observed number of individuals and expected number of individuals with each phenotype in turn.

In a monohybrid cross between two individuals that showed the same phenotype, 160 offspring were produced. 36 of these offspring showed a different phenotype to both parents for the same characteristic.

The characteristic is controlled by a single gene with one dominant allele and one recessive allele.

Which of the following expressions calculates the value required for the mathematical test for this cross?

(Assume no mutations and that no genotype results in the death of individuals.)

A $\frac{4}{120} + \frac{4}{40}$

B $\frac{4}{124} + \frac{4}{36}$

C $\frac{16}{120} + \frac{16}{40}$

D $\frac{16}{124} + \frac{16}{36}$

E $\frac{32}{160}$

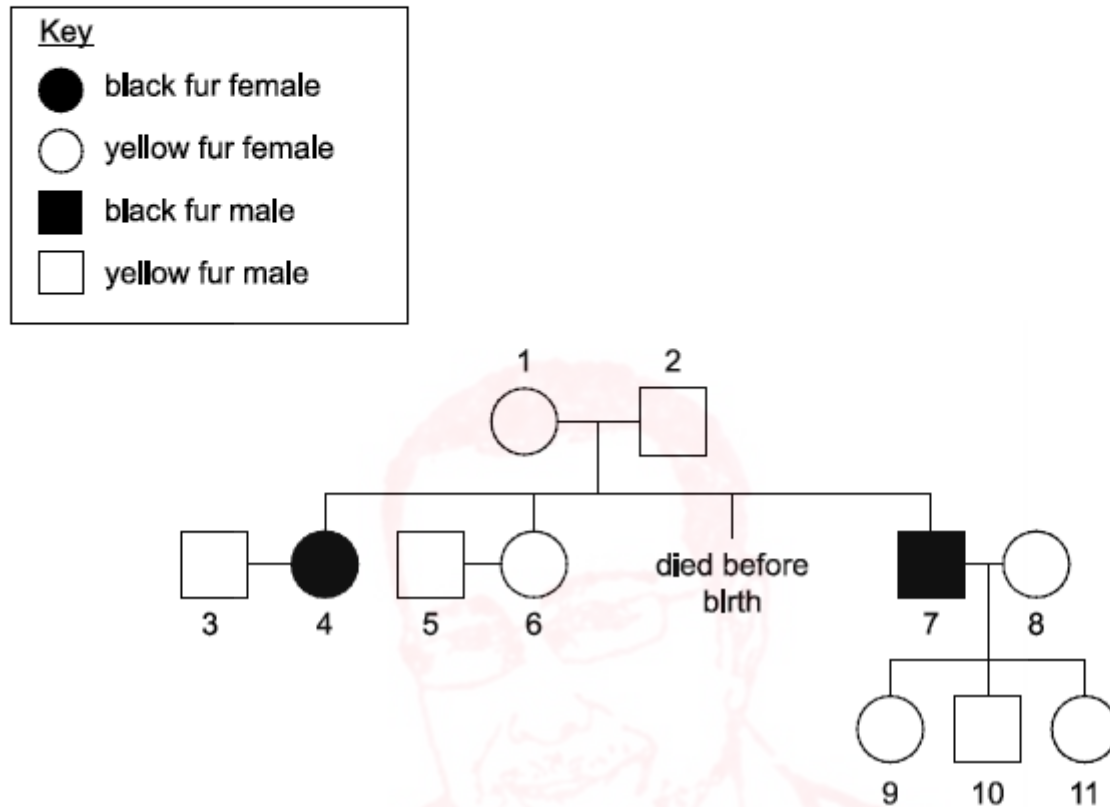
F $\frac{44}{124} + \frac{44}{36}$

G $\left(\frac{44^2}{80}\right) + \left(\frac{44^2}{80}\right)$

H $\left(\frac{44^2}{124}\right) + \left(\frac{44^2}{36}\right)$

- 26** Fur colour in a mammal is controlled by a gene found on a chromosome in the nucleus. The gene has two alleles, one for yellow fur and one for black fur. Individuals that are homozygous for the yellow fur allele die before birth.

The diagram shows the inheritance of this characteristic in three generations of one family. All of the numbered individuals are alive.



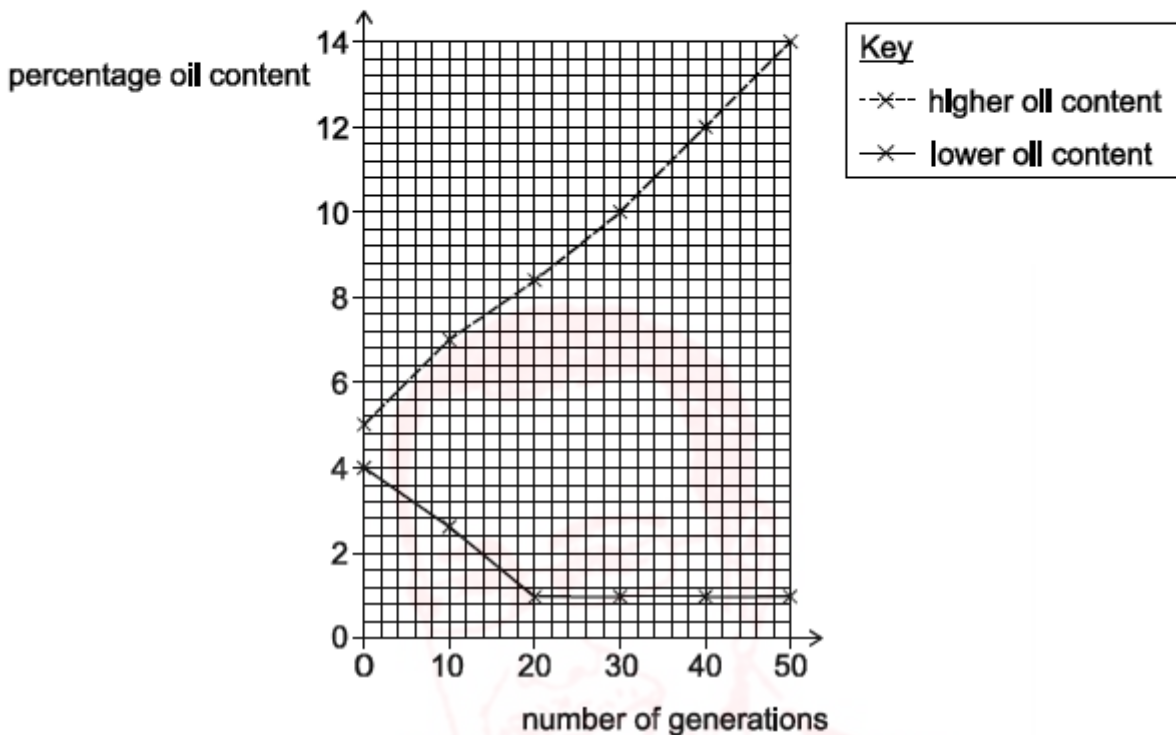
Which row of the table is correct?

	<i>dominant allele</i>	<i>number of copies of the black fur allele present in the genotypes of the live individuals in the diagram</i>	<i>expected phenotype ratio in offspring born from a cross between individuals 5 and 6</i>
A	black	2	2 : 1
B	black	13	3 : 1
C	black	4	2 : 1
D	black	2	3 : 1
E	yellow	4	2 : 1
F	yellow	13	3 : 1
G	yellow	2	2 : 1
H	yellow	13	2 : 1

28 There is significant variation in the amount of oil present in maize grains.

In an experiment, maize grains were tested for their oil content and only those with either highest or lowest oil content were selected and planted. When this generation of plants matured and produced maize grains, these were tested for their oil content and the selection process was repeated. This was done over fifty generations of maize.

All plants were grown in the same conditions. The mean mass per maize grain was 0.4 g and did not change over the fifty generations. The results are shown in the graph.



Which of the following statements about the experiment is/are correct?

- 1 The change in oil content over the fifty generations was due to natural selection.
- 2 There was a 180% increase in the oil content of the grains with a higher oil content over the fifty generations.
- 3 The change in mass of oil in the higher oil content grains over the fifty generations was 0.036 g.

- A none of them
- B 1 only
- C 2 only
- D 3 only
- E 1 and 2 only
- F 1 and 3 only
- G 2 and 3 only
- H 1, 2 and 3

- 30 In flour beetles one gene controlling eye colour is located on chromosome 5. Flour beetles have two copies of chromosome 5 in each body cell. One allele causes black eyes and a second allele causes red eyes.

The allele for black eye colour (B) is dominant over the allele for red eye colour (b).

$\frac{3}{4}$ of the **alleles** present in a population of 1600 flour beetles were the dominant B allele.

Which of the following statements is/are correct?

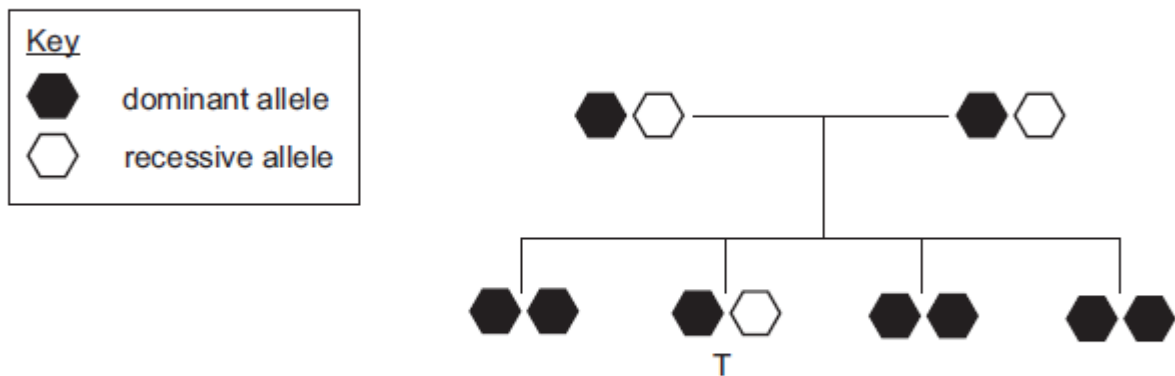
(Assume that inheritance of the two alleles is a random process.)

- 1 The expected number of flour beetles with black eyes is 1500.
- 2 The body cells of the flour beetles are diploid.
- 3 The expected ratio of homozygous black eye beetles to heterozygous black eye beetles to red eye beetles will be 1 : 2 : 1

- A none of them
- B 1 only
- C 2 only
- D 3 only
- E 1 and 2 only
- F 1 and 3 only
- G 2 and 3 only
- H 1, 2 and 3



- 41** The diagram shows the inheritance of a characteristic controlled by a single gene. Two organisms reproduce sexually and have four offspring, one offspring at a time.



Individual T goes on to have a single offspring with an unrelated individual who has a recessive phenotype. The offspring of T has a dominant phenotype.

What is the ratio of dominant to recessive alleles for all of the individuals in this diagram, as well as T's mate and their one offspring?

- A 3:5
- B 5:3
- C 7:1
- D 1:7
- E 3:1
- F 1:3
- G 2:1
- H 1:2

- 44** A recessive condition is found within a human population. There were 5000 births in this population within one year. Of these births, 8% had the condition and 32% were homozygous dominant.

One healthy cheek cell is analysed from each person born in this year.

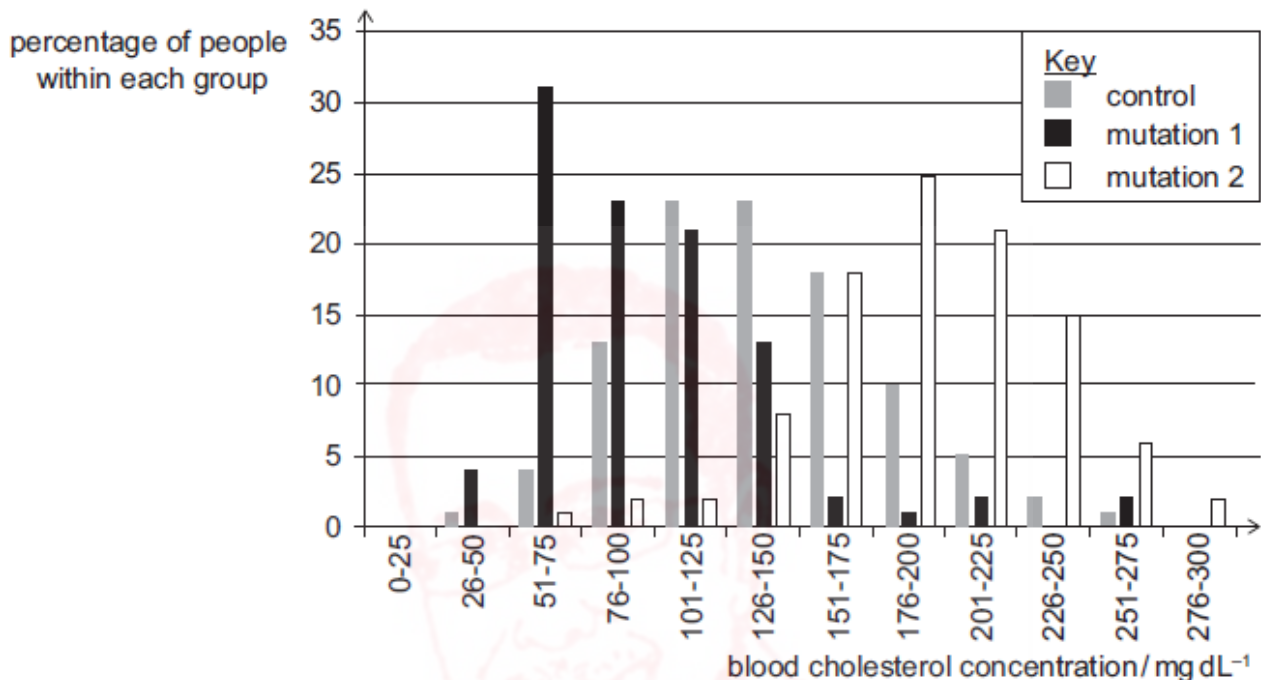
How many recessive alleles and dominant alleles are present?

(Assume that no new mutations occur.)

	<i>recessive alleles</i>	<i>dominant alleles</i>
A	400	1600
B	400	4600
C	3400	1600
D	3400	4600
E	3400	6200
F	3800	1600
G	3800	4600
H	3800	6200

- 45** A study was carried out into the effect of liver protein Z on the risk of developing coronary heart disease, which is often associated with high blood cholesterol. Z binds to another protein in the membrane of liver cells that transports cholesterol from the blood into cells. This binding blocks the function of the transport protein.

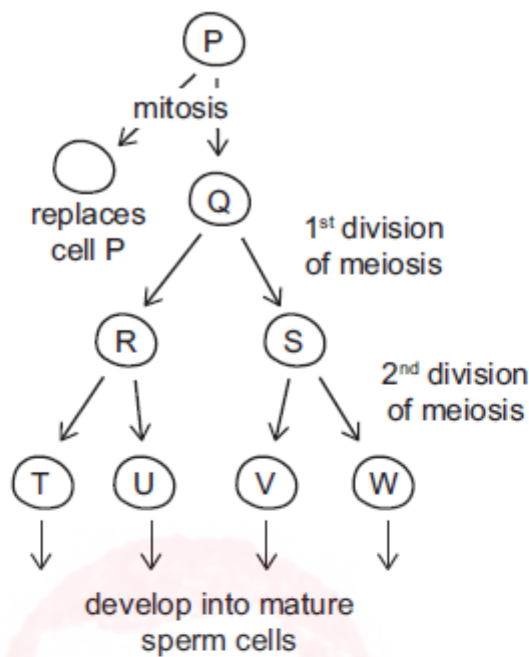
Blood cholesterol levels were measured in three different groups of people. One group was a control group and contained no mutations in the gene for Z. The second group all had the same mutation in the gene (called mutation 1). This mutation occurs in the final section of the gene. A third group all had a different mutation in the gene (called mutation 2), but this was in the first section of the gene. The results are shown in the graph.



Which of the following can be correctly concluded from these results?

- 1 Changes in the first section of protein Z stop it from binding to the cholesterol transport protein.
 - 2 Mutation 1 could result in an increase in the concentration of cholesterol inside liver cells.
 - 3 Of the three groups, people in the control group are least likely to develop coronary heart disease.
- A none of them
- B 1 only
- C 2 only
- D 3 only
- E 1 and 2 only
- F 1 and 3 only
- G 2 and 3 only
- H 1, 2 and 3

- 48** The diagram shows the production of sperm cells in a healthy mammal. Cell P divides. One daughter cell goes on to replace cell P, and the other daughter cell is called Q in the diagram.



Each mitotic cell cycle takes 14 hours.

The diploid number of chromosomes in this mammal is 68.

Which of the following statements is/are correct?

- 1 Cell P is a type of stem cell.
- 2 Cells T, U, V and W each contain 23 chromosomes.
- 3 In 112 hours, 128 replacements of cell P are made.

- A none of them
- B 1 only
- C 2 only
- D 3 only
- E 1 and 2 only
- F 1 and 3 only
- G 2 and 3 only
- H 1, 2 and 3

57 One form of genetic variation within a population depends on the number of alleles per gene.

Four populations of the same animal species each have the same gene in the same position on a chromosome.

Each population has a different number of alleles for this gene as shown in the table.

<i>population</i>	<i>number of alleles for the same gene</i>
P	3
Q	4
R	5
S	6

Assume that in the heterozygous state, the genotype is the same whether an allele is inherited from the mother or the father.

Which of the following is/are correct for this gene?

(Assume that no mutations occur in this gene.)

- 1** The theoretical number of different genotypes in population S is 6 more than in population R.

2

<i>theoretical number of different homozygous genotypes in population</i>			
P	Q	R	S
3	4	5	6

- 3** In populations P, Q and R, there are more different homozygous combinations than there are different heterozygous combinations.

- A** none of them
B 1 only
C 2 only
D 3 only
E 1 and 2 only
F 1 and 3 only
G 2 and 3 only
H 1, 2 and 3

59 A fertilised egg cell is spherical and has a volume of $0.12 \mu\text{m}^3$.

In the initial stages of development, the fertilised egg cell undergoes several rounds of cleavage. During cleavage, cells divide by mitosis but do not grow. Assume that when cells undergo cleavage, the daughter cells are spherical and are identical to each other.

Which of the following statements about the cells present after three rounds of cleavage is/are correct?

- 1 Each cell will contain $\frac{1}{8}$ of the DNA present in the fertilised egg cell.
- 2 The volume of each cell will be $0.03 \mu\text{m}^3$.
- 3 The diameter of the cells is 50% of that of the fertilised egg cell.

- A none of them
- B 1 only
- C 2 only
- D 3 only
- E 1 and 2 only
- F 1 and 3 only
- G 2 and 3 only
- H 1, 2 and 3



f) Using examples, describe the changes that can occur in DNA sequences and explain how these changes can lead to diseases.

[10 marks]

Answer:

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Question B2

- a) From the following list of organisms identify one that can reproduce itself (i) without using mitosis or meiosis, and (ii) using *either* mitosis alone or meiosis.

- 1 *Homo sapiens*
- 2 *Fragaria ananassa* (strawberry)
- 3 *Escherichia coli*

[2 marks]

Answer:

(i)

(ii)

- b) For the processes of mitosis and meiosis, draw separate line graphs to show how the relative amount of DNA in a single healthy dividing cell changes with time.

You should label the axes on the graphs.

(Assume that no mutations occur.)

[3 marks]

Answer:

Mitosis

Meiosis

SMASHING!!!

- c) Calculate how many possible combinations of chromosomes could be produced in each gamete during sexual reproduction in humans (assuming no recombination). **[2 marks]**

Answer:

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- d) A female has a recessive disease-causing allele on one of her non-sex-determining chromosomes. She mates with a male with the same disease-causing allele on one of his chromosomes. They have one child. Assuming that no mutations occur, what is the probability that:

- (i) this child will have the disease? **[1 mark]**

Answer:

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- (ii) this child is male and does not have the disease? **[2 marks]**

Answer:

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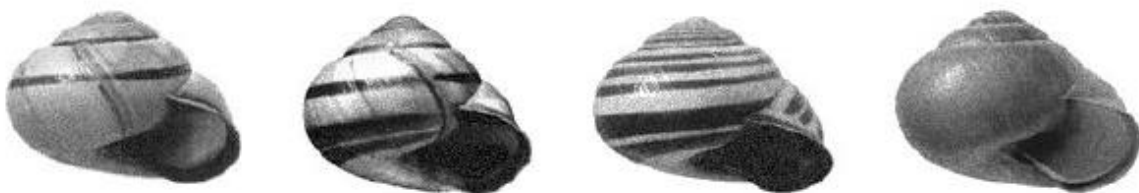
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Section 2 Topic 16 **Q# 298/** Cambridge/2016SP/Section 2/ BIOLOGY NSAA/ www.SmashingScience.org

Question 6

Look at the image below.



- d) In terms of genetics, the allele for 'unbanded' is dominant to 'banded'. If I breed some homozygous 'unbanded' snails together with homozygous 'banded' snails, what will be the F₁ phenotypes and genotypes? [2 marks]

- e) If I breed the F1 generation from the previous cross together, and get 240 offspring, what will be the estimated numbers of each phenotype and genotype in the next generation? [4 marks]



- 30** In flour beetles one gene controlling eye colour is located on chromosome 5. Flour beetles have two copies of chromosome 5 in each cell. One allele causes black eyes and a second allele causes red eyes.

The allele for black eye (B) is dominant over the allele for red eye (b).

$\frac{3}{4}$ of the **alleles** present in a population of 1600 flour beetles were the dominant B allele.

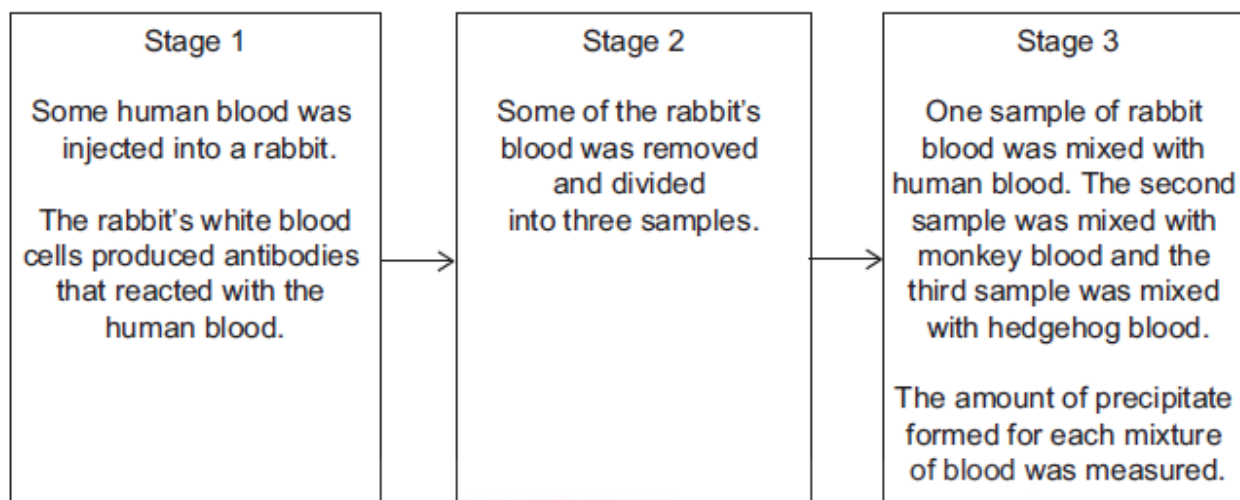
Which of the following statements is/are correct?

(Assuming that inheritance of the two alleles is a random process.)

- 1 The expected number of flour beetles with black eyes is 1500.
 - 2 The body cells of the flour beetles are diploid.
 - 3 The expected ratio of homozygous black eye beetles to heterozygous black eye beetles to red eye beetles will be 1 : 2 : 1
- A none of them
- B 1 only
- C 2 only
- D 3 only
- E 1 and 2 only
- F 1 and 3 only
- G 2 and 3 only
- H 1, 2 and 3



- 60** An investigation was carried out to discover the evolutionary relationships between three different species of mammal, a human, a monkey and a hedgehog, as shown in the flow diagram:



When an antigen binds to an antibody, a precipitate is formed, which is measured in stage 3.

Some of the results for stage 3 are shown in the table.

P and Q each represent one of the non-human mammals.

<i>species of mammal</i>	<i>amount of precipitate formed / arbitrary units</i>
P	58
Q	17

Which row is correct for this investigation?

	<i>biological molecules that form antibodies in stage 1</i>	<i>the amount of precipitate formed for the sample with human blood in stage 3 / arbitrary units</i>	<i>species Q</i>
A	amino acids	greater than 58	monkey
B	amino acids	greater than 58	hedgehog
C	amino acids	less than 17	monkey
D	amino acids	less than 17	hedgehog
E	nucleotides	greater than 58	monkey
F	nucleotides	greater than 58	hedgehog
G	nucleotides	less than 17	monkey
H	nucleotides	less than 17	hedgehog

e) Discuss:

- (i) how different mechanisms of reproduction affect the levels of variation in the next generation;
- (ii) how variation affects the likelihood of survival in a changing environment.

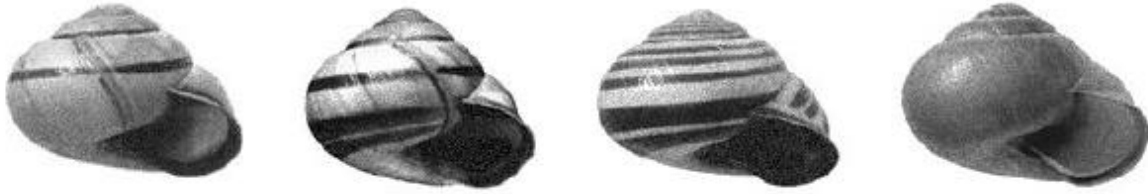
[10 marks]

Answer:



Question 6

Look at the image below.



- b) These snails do in fact belong to the same species, and each of the colour/stripe forms is maintained at very consistent frequencies in the population across time. When such variation is maintained in the population by natural selection, we call it a stable polymorphism. With reference to natural selection, explain why stable polymorphisms are relatively rare in nature. [3 marks]

Answer:

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- c) In this case, birds encounter the most abundant forms more frequently and can develop better 'search images', making it easier to find that form in future. Suggest how the variation in snail shells might be maintained in a population. [2 marks]

Answer:

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Biology

Question 5

Look at the following table.

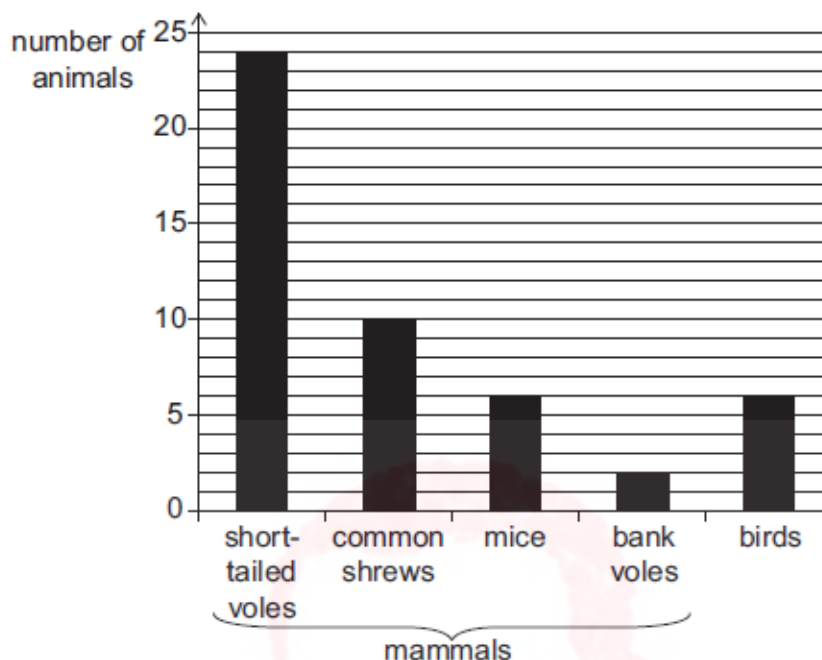
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- f) Discuss how the differences in these sequences might have arisen, and the possible evolutionary consequences of this variation. [12 marks]



- 24** A study was carried out into the food sources of barn owls. Owls regurgitate the undigested remains of their prey as pellets. Analysis of these pellets was used to identify the food eaten by one owl, over a period of 2 weeks. The chart shows the number of animals in the owl's diet. The findings show that most of the owl's diet was mammals.



A second study was carried out over the following 2 weeks to find the change in the population of mice in the owl's habitat. The table shows the data obtained for the second study.

number of births	242
number of deaths	207
number joining from another population	11
number leaving to join another population	21

What is the percentage of mammals in the owl's diet that are mice in the first study, what is the mean change in the population of mice per week in the second study, and what can be concluded about the change in the number of mice in the owl's diet during the second study compared to the first study?

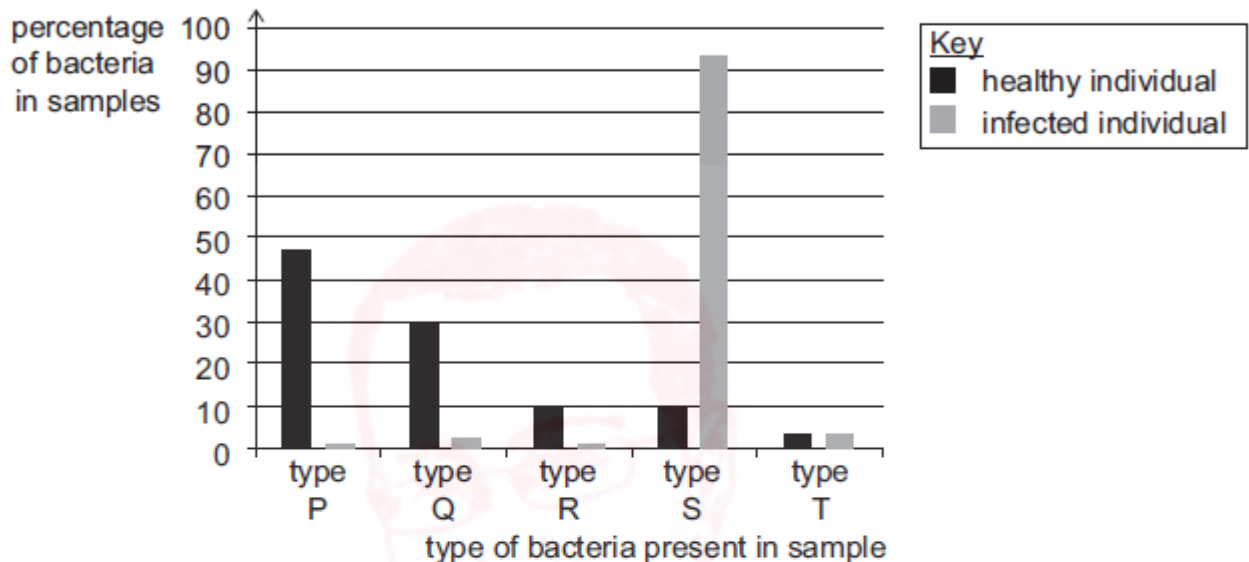
	percentage of mammals that are mice in the owl's diet	mean change in the population of mice per week	conclusion about the change in the number of mice in the owl's diet
A	12.5%	12.5	likely to increase
B	12.5%	25.0	likely to increase
C	12.5%	25.0	unlikely to increase
D	12.5%	45.0	insufficient evidence
E	14.3%	12.5	insufficient evidence
F	14.3%	12.5	unlikely to increase
G	14.3%	25.0	likely to increase
H	14.3%	45.0	unlikely to increase

- 43** A number of patients in a hospital were infected with the same bacterial pathogen. The symptoms of this infection included pain in the abdomen, sickness and loss of appetite partly resulting from decreased production of acid in the stomach.

The bacteria present in their digestive systems were compared with those of healthy volunteers.

Samples were taken from each person and examined in order to identify the type of bacteria present and their relative proportions.

The results of the study are shown in the chart.



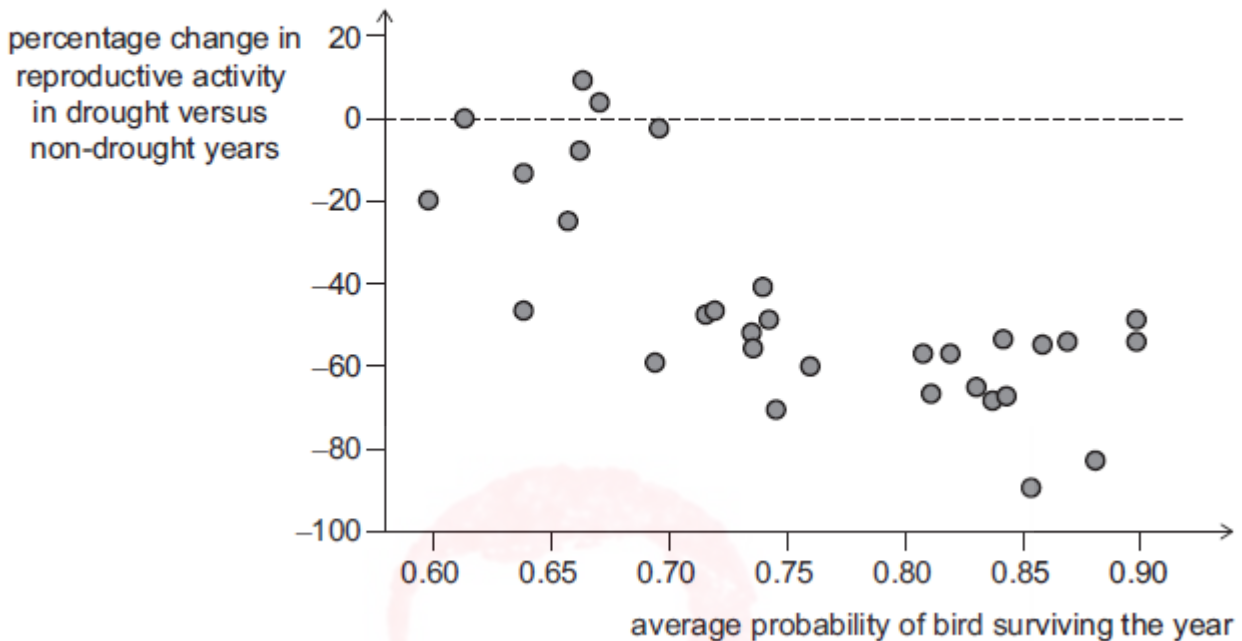
Which of the following statements could be correct?

- 1 Type S and type T feed on different biological molecules.
- 2 The DNA sequence of bacterial genes was used to classify the bacteria.
- 3 Type P, type Q and type R reduce in number because they require an alkaline environment.

- A** none of them
- B** 1 only
- C** 2 only
- D** 3 only
- E** 1 and 2 only
- F** 1 and 3 only
- G** 2 and 3 only
- H** 1, 2 and 3

45 A group of scientists studied the effect of droughts on the reproduction rate and lifespan of different species of birds.

The graph shows their results. Each data point refers to a different species.



Which of these statements is/are correct?

- 1 The overall trend for this data shows that birds with shorter life expectancies tended to change their reproduction rates less in drought years.
- 2 Some birds were found to reproduce more in drought years than in non-drought years.
- 3 These birds were being studied for the effect of a biotic factor on their population size.

- A none of them
- B 1 only
- C 2 only
- D 3 only
- E 1 and 2 only
- F 1 and 3 only
- G 2 and 3 only
- H 1, 2 and 3

58 Commercial varieties of tomato are produced from wild varieties of tomato.

The genetic diversity of tomatoes can be measured and expressed as a number.

A population of wild varieties of tomato was found to have a genetic diversity of 0.30.

The table shows the genetic diversity of a population of commercial tomatoes grown at different times.

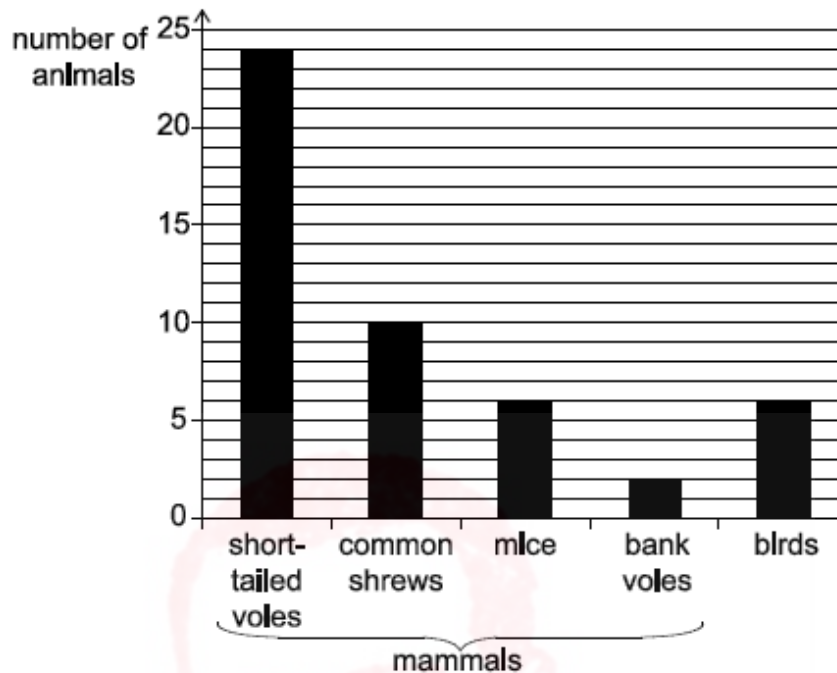
<i>year</i>	<i>genetic diversity</i>
pre-1960	0.10
1960	0.05
1980	0.20
2000	0.30

Which of the following statements about these tomatoes could be correct?

- 1 Selective breeding of tomatoes occurred before 1960.
- 2 The addition of genetic material, enabling the tomatoes to produce memory cells so that they are resistant to diseases, increased the genetic diversity from 1960 onwards.
- 3 The average rate of increase in genetic diversity per day between 1960 and 2000 is approximately $\frac{25}{1460\,000}$.
- 4 The increase in genetic diversity was 50% greater during the 1960 to 1980 period than the 1980 to 2000 period.

- A 1 and 2 only
- B 1 and 3 only
- C 1 and 4 only
- D 2 and 3 only
- E 2 and 4 only
- F 1, 2 and 3 only
- G 1, 3 and 4 only
- H 2, 3 and 4 only

- 23** A study was carried out into the food sources of barn owls. Owls regurgitate the undigested remains of their prey as pellets. Analysis of these pellets was used to identify the food eaten by one owl, over a period of 2 weeks. The chart shows the number of animals in the owl's diet. The findings show that most of the owl's diet was mammals.



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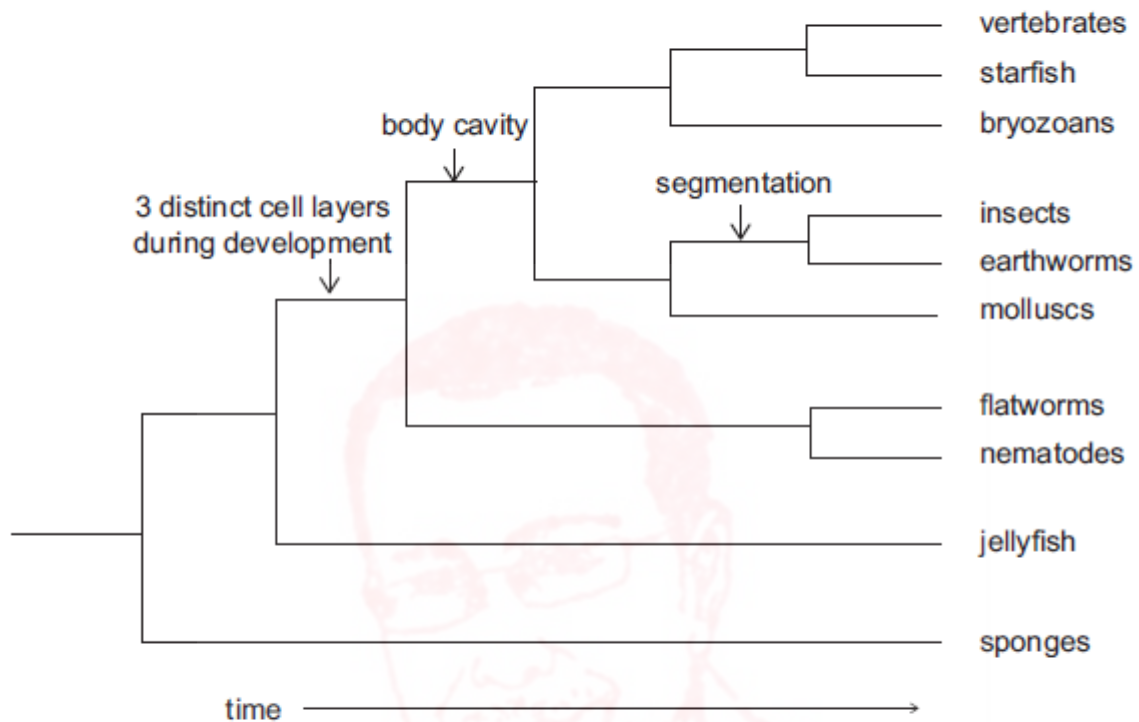
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	<i>percentage of mammals that are mice in the owl's diet</i>	<i>mean change in the population of mice per week</i>	<i>conclusion about the change in the number of mice in the owl's diet</i>
A	12.5%	12.5	likely to increase
B	12.5%	25.0	likely to increase
C	12.5%	25.0	unlikely to increase
D	12.5%	45.0	insufficient evidence
E	14.3%	12.5	insufficient evidence
F	14.3%	12.5	unlikely to increase
G	14.3%	25.0	likely to increase
H	14.3%	45.0	unlikely to increase

Question B1

The diagram shows an evolutionary tree for a kingdom of organisms. This tree was constructed over 20 years ago using shared observable features to group these organisms into smaller groups. The time at which three of these shared features first appeared is shown on the evolutionary tree. Each branching point in the tree indicates the time at which groups of organisms diverged from a common ancestor.



a) Identify the kingdom represented in this evolutionary tree.

[1 mark]

Answer:

.....

.....

b) Recently, molecular evidence has changed our understanding of these relationships. Based upon each of the three findings below, what conclusions about evolution can you draw?

(i) Insects and earthworms are not closely related to each other.

[1 mark]

Answer:

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(ii) Nematodes and insects, both of which undergo moulting, are very closely related.

[2 marks]

Answer:

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(iii) Flatworms, which all lack a true body cavity, are not actually a single group. Some diverged at the base of the tree, some are related to the molluscs, and some are related to starfish and vertebrates.

[2 marks]

Answer:

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- c) Briefly describe two benefits of using molecular evidence, rather than visible characteristics, to construct trees.

[2 marks]

Answer:

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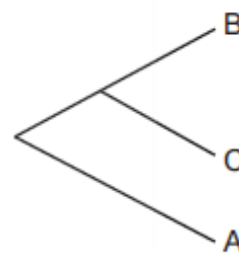
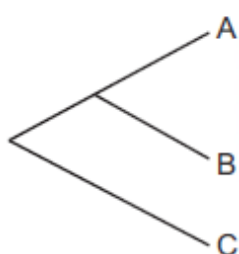
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- d) The following three tree diagrams show **all** of the possible relationships between 3 different organisms.



How many possible tree diagrams are there with 4 organisms?

[2 marks]

Answer:

SMASHING!!!

e) Using examples, discuss the different ways by which we can measure biodiversity.

[10 marks]

Answer:





f) Discuss the factors that may affect the spread and photosynthetic rate of the invasive plant.

[10 marks]

Answer:

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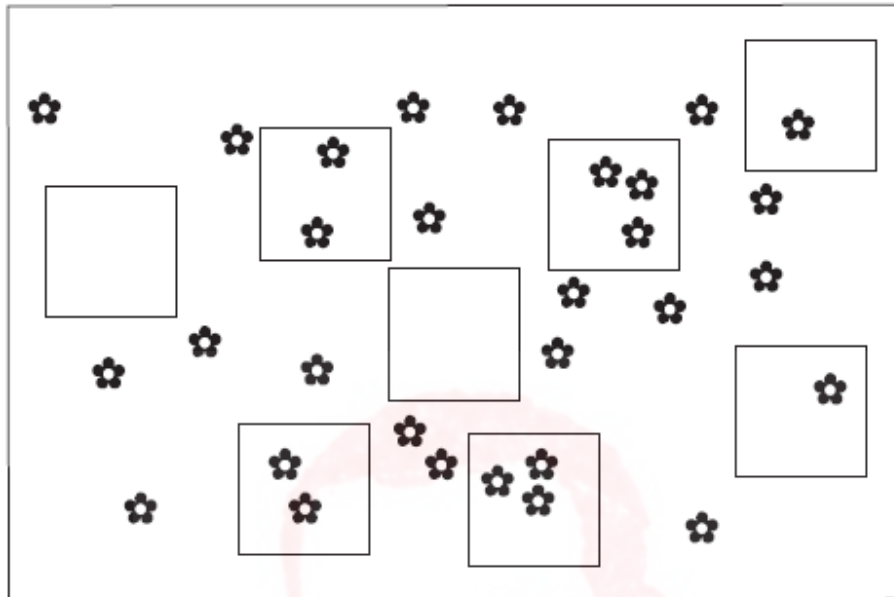




Question B2

The diagram below shows eight $2\text{ m} \times 2\text{ m}$ quadrats that have been placed into a $14\text{ m} \times 10\text{ m}$ field that has recently been colonised by a small invasive plant (each plant is shown by a flower symbol).

[diagram not to scale]



- a) Describe one benefit **and** one problem associated with using quadrats in a study like this.

[2 marks]

Answer:

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- b) Calculate the frequency of occurrence of the species in the quadrats.

[1 mark]

Answer:

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c) Calculate the mean number of plants found per square metre in the quadrats.

[2 marks]

Answer:

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d) For the field as a whole, this population grows by 70 individuals per week.

How long will the population take to reach an average density of two plants per square metre in the 14 m × 10 m field?

[2 marks]

Answer:

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e) The invasive plant only produces flowers once every 5 years.

Explain why the plant produces flowers, and why flowers might be produced on this timescale.

[3 marks]

Answer:

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Question 6

Look at the image below.



- a) Using experiments, how could you tell if each of these snails belonged to the same species? [2 marks]

Answer:

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Biology

Question 5

Look at the following table.

	320											330											340										
Organism 1	G	C	C	T	A	G	G	C	A	T	T	A	C	G	C	T	A	C	G	T	C	G	C	A	T	T	A	T	A	C			
Organism 2	G	C	T	A	A	G	G	C	A	C	T	A	C	G	C	T	A	C	G	T	C	G	C	T	T	A	A	T	A	G			
Organism 3	G	C	T	A	A	G	C	A	C	T	A	C	G	C	T	A	C	G	T	C	G	C	T	T	A	A	T	A	G	C			
Organism 4	G	C	T	A	A	G	G	C	A	C	T	A	C	G	C	T	A	C	G	T	C	G	C	A	T	T	A	T	A	C			
Organism 5	G	C	C	A	A	G	G	C	A	C	T	A	C	G	C	T	A	C	G	T	C	G	C	A	T	T	A	T	A	C			
Organism 6	G	C	T	A	A	G	G	C	A	C	T	A	C	G	C	T	A	C	G	T	C	G	C	T	T	T	A	T	A	C			
Organism 7	G	C	T	A	A	G	A	G	A	C	T	A	C	G	G	A	A	C	G	C	C	G	C	T	T	A	A	T	A	G			

- d) Each organism in the table belongs to a different species. Based on the sequences, state which organisms are (i) the most related to each other, and (ii) the least related to each other.

[4 marks]

Answer:

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- e) If organisms 1-6 are all Eukaryotes, which domain(s) of life could organism 7 belong to?

[2 marks]

Answer:

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SMASHING!!!

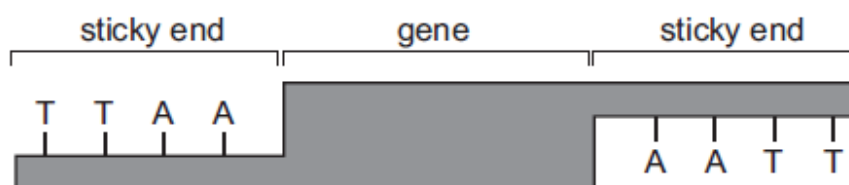
- f) Explain how you would conduct a study to compare the proportions of pink, banded snails in two different habitats. Consider how you would avoid bias in your samples. [12 marks]

Answer:

.....



- 43** An enzyme called EcoRI is used to cut out a gene from the middle of a human chromosome. This process produces sticky ends as shown in the diagram.



When guanine separates from its complementary base, three hydrogen bonds are broken, whereas two are broken when the other pair of bases separate.

Which row is correct?

	<i>EcoRI is a</i>	<i>the number of base-pairing hydrogen bonds broken when this gene was cut out using EcoRI</i>
A	restriction enzyme	16
B	restriction enzyme	20
C	restriction enzyme	24
D	ligase	16
E	ligase	20
F	ligase	24

49 Some varieties of plant crops, like maize, can survive at low temperatures, such as 4 °C.

Scientists identified protein Z that they believe to be involved in the response to low temperatures in maize.

One method of studying how plants survive at low temperatures is to investigate the levels of ion leakage from cells damaged by the low temperatures. Higher levels of ion leakage are associated with lower levels of survival.

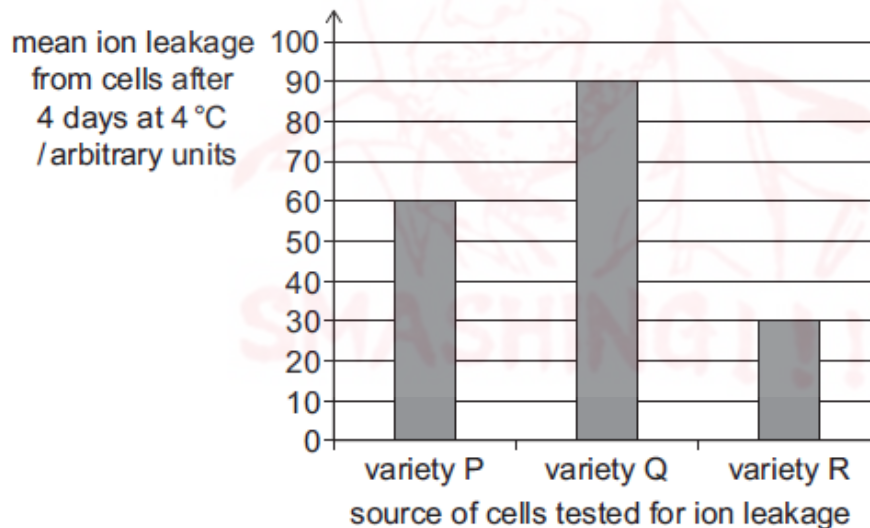
The scientists measured the levels of ions leaking from cells of three varieties of maize.

<i>variety of maize</i>	<i>description</i>
P	normal maize plant
Q	contains a single base pair insertion in the DNA near the start of the gene coding for protein Z
R	is genetically modified to produce the highest levels of protein Z

Other than the changes listed in the table, the plants were genetically identical.

Ion leakage from samples of cells of each variety was measured after the plants had been kept at 4 °C for 4 days. All other variables were kept constant.

The results of this investigation are shown in the chart.



49 Which of the following statements is/are correct?

- 1 The cell wall in maize cells controls the leakage of ions from the cell at 4 °C.
- 2 Inserting an extra base pair near the start of the gene for protein Z could change the overall amino acid sequence of the protein.
- 3 The presence of protein Z in maize cells increases the chance of the maize plant surviving at 4 °C.

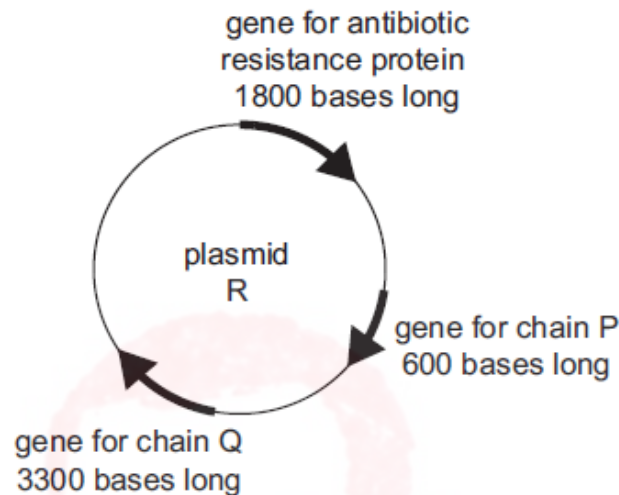
- A none of them
- B 1 only
- C 2 only
- D 3 only
- E 1 and 2 only
- F 1 and 3 only
- G 2 and 3 only
- H 1, 2 and 3



- 60** A particular functional protein consists of two smaller chains of amino acids joined together, chain P and chain Q. A group of scientists made this protein using bacterial cells.

They created recombinant plasmid R by inserting the genes for chain P and chain Q into a plasmid. They also inserted a gene for an antibiotic resistance protein into the plasmid so that cells containing the recombinant plasmid could be selected using antibiotics.

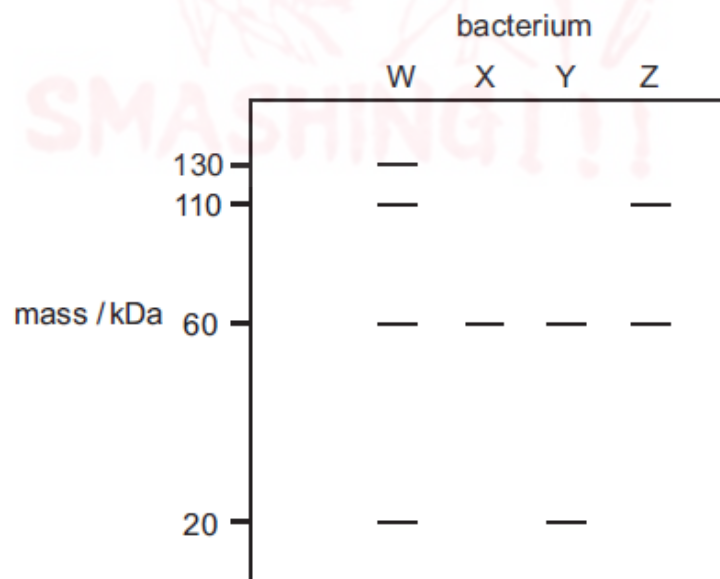
A map of the recombinant plasmid is shown:



This process is not efficient and must be carried out several times to be certain of creating plasmid R.

Four plasmids were made and individually moved into four bacterial cells, labelled W, X, Y and Z.

The proteins encoded by the genes in the plasmid in the bacterial cells were checked by separating the proteins based on their mass, producing the results as shown in the following diagram.



Each band represents a protein or amino acid chain of the given mass.

Assume that one amino acid has a mass of 0.1 kDa.

60 Which of the following statements is/are correct?

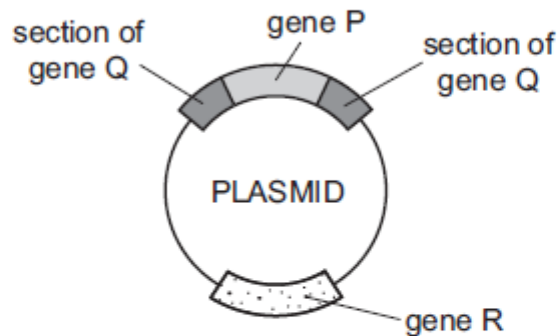
- 1** W is the only bacterium with the fully functional protein.
- 2** The proteins/amino acid chain(s) in Y and Z are from bacteria that can each only produce one of the parts of the functional protein.
- 3** The DNA ligase enzymes may not have functioned as intended when creating the plasmid that is in bacterium X.

- A** none of them
- B** 1 only
- C** 2 only
- D** 3 only
- E** 1 and 2 only
- F** 1 and 3 only
- G** 2 and 3 only
- H** 1, 2 and 3



- 56** A plasmid contains genes Q and R. Gene Q codes for resistance to the antibiotic *q*. Gene R codes for resistance to antibiotic *r*.

The plasmid was genetically engineered to contain the human gene P. This gene was inserted into gene Q in the plasmid preventing gene Q from working.



A mixture of the original plasmid and the genetically-engineered plasmid were available to be taken up by bacterial cells. The bacterial cells took up either the original plasmid, or the genetically-engineered plasmid, or neither of the plasmids.

All these bacteria were allowed to grow and form colonies on agar plates in the absence of both antibiotics.

40 colonies formed.

Cells from each of the 40 colonies were grown on three agar plates with different contents.

The table shows the number of colonies that grew on each of the three plates.

<i>contents of agar plate</i>	<i>number of bacterial colonies able to survive on the agar plate</i>
no antibiotic	40
antibiotic <i>q</i> only	8
antibiotic <i>r</i> only	24

What percentage of the original 40 bacteria now contain gene P?

(Assume that no mutations occur.)

- A 16%
- B 20%
- C 33%
- D 40%
- E 60%
- F 80%

- e) We can use different restriction enzymes to cut DNA at different sites. Another restriction enzyme is *Bam*HI. By studying the fragments produced by different combinations of restriction enzymes we can produce a map of the cutting sites of these enzymes.

Use the data in the table below to produce a map of the cutting sites of restriction enzymes. This map should be drawn onto a circle of bacterial plasmid DNA, the total length of which is 18 kb. Distances between the cut sites should be identified. [4 marks]

<i>enzyme used</i>	<i>fragment sizes produced / kb</i>
<i>Eco</i> RI alone	6, 12
<i>Bam</i> HI alone	7.5, 10.5
<i>Eco</i> RI and <i>Bam</i> HI together	3, 3, 4.5, 7.5

Answer:



f) Suggest how enzymes like *EcoRI* could be used in genetic engineering.

[3 marks]

Answer:

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Section 1 Mark Scheme

Q# 1/ Topic 1 Cambridge/2024/ESAT/ Biology/ Q# 11 /www.SmashingScience.org/

The answer is: 1 and 3 only.

Mitochondria are organelles involved in aerobic respiration in eukaryotic cells. Bacteria do not contain these organelles, and neither do mature red blood cells. All stem cells and potato cells will contain mitochondria.

Q# 2/ Topic 1 Cambridge/2023/Section 1/ Biology NSAA/ Q# 67 /www.SmashingScience.org/

Q67 | E

Q# 3/ Topic 1 Cambridge/2021/Section 1/ Biology NSAA/ Q# 73 /www.SmashingScience.org/

Q73 | H

Q# 4/ Topic 1 Cambridge/2021/Section 1/ Biology NSAA/ Q# 62 /www.SmashingScience.org/

Q62 | B

Q# 5/ Topic 1 Cambridge/2020/Section 1/ Biology NSAA/ Q# 62 /www.SmashingScience.org/

Q62 | F

Q# 6/ Topic 1 Cambridge/2019/Section 1/ Biology NSAA/ Q# 64 /www.SmashingScience.org/

64 | C

Q# 7/ Topic 1 Cambridge/2019/Section 1/ Biology NSAA/ Q# 55 /www.SmashingScience.org/

55 | D

Q# 8/ Topic 1 Cambridge/2017/Section 1/ Biology NSAA/ Q# 62 /www.SmashingScience.org/

62 | D

Q# 9/ Topic 1 Cambridge/2017/Section 1/ Biology NSAA/ Q# 60 /www.SmashingScience.org/

60 | D

Q# 10/ Topic 1 Cambridge/2016/Section 1/ Biology NSAA/ Q# 62 /www.SmashingScience.org/

62 | B

Q# 11/ Topic 1 Cambridge/2016/Section 1/ Biology NSAA/ Q# 57 /www.SmashingScience.org/

57 | A

Q# 12/ Topic 2 Cambridge/2024/ESAT/ Biology/ Q# 26 /www.SmashingScience.org/

The answer is: 2 and 3 only.

Starch is found in plant cells, not animal cells such as a liver cell, so statement 1 is incorrect.

Within the liver cell's DNA there would be one pair of sex chromosomes. If the cell was from a male these would be XY and in a female these would be XX. In either case there is at least one X chromosome, so statement 2 is correct.

An adult liver cell is a diploid body cell so it will contain the same genes as all other diploid body cells, including the gene for amylase, so statement 3 is correct.

Q# 13/ Topic 2 Cambridge/2020sp/Section 1/ Biology NSAA/ Q# 79 /www.SmashingScience.org/

79

The answer is option G.

Starch is found in plant cells, not animal cells such as a liver cell, so statement 1 is incorrect. Within the liver cell's DNA there would be one pair of sex chromosomes. If the cell was from a male these would be XY and in a female these would be XX. In either case there is at least one X chromosome, so statement 2 is correct. An adult liver cell is a diploid body cell so it will contain the same genes as all other diploid body cells, including the gene for amylase, so statement 3 is correct.

Q# 14/ Topic 2 Cambridge/2020/Section 1/ Biology NSAA/ Q# 64 /www.SmashingScience.org/

Q64

| D

Q# 15/ Topic 2 Cambridge/2016/Section 1/ Biology NSAA/ Q# 64 /www.SmashingScience.org/

64 | E

Q# 16/ Topic 3 Cambridge/2024/ESAT/ Biology/ Q# 8 /www.SmashingScience.org/

The answer is: 1 and 3 only.

An increase in pH may move the reaction closer to the optimum pH for this enzyme so the reaction would progress to completion more rapidly, so 1 is correct. Likewise, a decrease in pH may move the conditions towards the optimum, so 3 is also correct. Both 2 and 4 are incorrect. In the case of 2, a reduction in substrate will lead to less product being made, so the plot for X should plateau at a lower level than Y. As for 4, an increase in substrate would lead to more product being formed so the plateau for X should be higher than Y.

Q# 17/ Topic 3 Cambridge/2024/ESAT/ Biology/ Q# 5 /www.SmashingScience.org/

The answer is: 1 and 2 only.

The main factors affecting the rate of photosynthesis are light intensity, temperature and carbon dioxide concentration. Any change in the level of a factor will affect the rate of reaction and the process will be limited by the factor which is in the shortest supply.

In the case of temperature, the rate of reaction will increase until the optimum temperature for the enzymes controlling the reaction is reached, as long as the other factors are present in sufficient amounts. Therefore statement 1 is correct. After this point the enzymes start to become denatured and no longer work, so statement 2 is correct. An increase in temperature produces an increase in kinetic energy and, up to a temperature of 22 °C the rate of photosynthesis also increases. However temperature does not increase the rate across the whole of the range studied as after the optimum temperature has been reached, the rate of photosynthesis decreases. Therefore statement 3 is incorrect.

Q# 18/ Topic 3 Cambridge/2023/Section 1/ Biology NSAA/ Q# 71 /www.SmashingScience.org/

Q71

| F

Q# 19/ Topic 3 Cambridge/2023/Section 1/ Biology NSAA/ Q# 64 /www.SmashingScience.org/

Q64

| F

Q# 20/ Topic 3 Cambridge/2022/Section 1/ Biology NSAA/ Q# 74 /www.SmashingScience.org/

Q74

| F



Q# 21/ Topic 3 Cambridge/2022/Section 1/ Biology NSAA/ Q# 71 /www.SmashingScience.org/

Q71 | G

Q# 22/ Topic 3 Cambridge/2021/Section 1/ Biology NSAA/ Q# 76 /www.SmashingScience.org/

Q76 | E

Q# 23/ Topic 3 Cambridge/2021/Section 1/ Biology NSAA/ Q# 67 /www.SmashingScience.org/

Q67 | D

Q# 24/ Topic 3 Cambridge/2020/Section 1/ Biology NSAA/ Q# 77 /www.SmashingScience.org/

Q77 | C

Q# 25/ Topic 3 Cambridge/2020/Section 1/ Biology NSAA/ Q# 72 /www.SmashingScience.org/

Q72 | C

Q# 26/ Topic 3 Cambridge/2020/Section 1/ Biology NSAA/ Q# 66 /www.SmashingScience.org/

Q66 | G

Q# 27/ Topic 3 Cambridge/2019/Section 1/ Biology NSAA/ Q# 71 /www.SmashingScience.org/

71 | D

Q# 28/ Topic 3 Cambridge/2019/Section 1/ Biology NSAA/ Q# 67 /www.SmashingScience.org/

67 | B

Q# 29/ Topic 3 Cambridge/2017/Section 1/ Biology NSAA/ Q# 68 /www.SmashingScience.org/

68 | H

Q# 30/ Topic 3 Cambridge/2016sp/Section 1/ Biology NSAA/ Q# 68 /www.SmashingScience.org/

68 | B

Q# 31/ Topic 3 Cambridge/2016/Section 1/ Biology NSAA/ Q# 71 /www.SmashingScience.org/

71 | H

Q# 32/ Topic 3 Cambridge/2016/Section 1/ Biology NSAA/ Q# 60 /www.SmashingScience.org/

60 | B

Q# 33/ Topic 3 Cambridge/2016/Section 1/ Biology NSAA/ Q# 58 /www.SmashingScience.org/

58 | C

Q# 34/ Topic 4 Cambridge/2024/ESAT/ Biology/ Q# 27 /www.SmashingScience.org/

The answer is A.

The question tells us that a cell is surrounded by a dilute glucose solution which has a lower concentration of glucose than the glucose in the cytoplasm of the cell. It also tells us that both water molecules and glucose molecules enter the cell.

There is net movement of water molecules into a cell by osmosis. So we know that the concentration of water molecules outside the cell must be higher than the concentration of water molecules in the cell. Osmosis is a type of passive movement and so will be unaffected by the chemical which inhibits respiration as it does not require energy from the cell to take place. So water molecules will move into the cell.

There is net movement of glucose into the cell against a concentration gradient as the concentration of glucose molecules is lower outside the cell than inside. Glucose molecules must therefore enter by active transport.

Active transport uses energy supplied by respiration. If respiration is inhibited, then active transport will no longer take place and glucose molecules will not be able to move into the cell.

Q# 35/ Topic 4 Cambridge/2024/ESAT/ Biology/ Q# 12 /www.SmashingScience.org/

The answer is A.

A change from 0.12 mol dm^{-3} to $0.084 \text{ mol dm}^{-3}$ gives an increase in percentage haemolysis (read graph from right to left) from 2% up to 72%, which is an increase of 70%. The increase is due to the uptake of water through osmosis into the cells, which occurs as a result of the reduction in the concentration of the NaCl solution.

Q# 36/ Topic 4 Cambridge/2023/Section 1/ Biology NSAA/ Q# 74 /www.SmashingScience.org/

Q74 | D

Q# 37/ Topic 4 Cambridge/2022/Section 1/ Biology NSAA/ Q# 76 /www.SmashingScience.org/

Q76 | F

Q# 38/ Topic 4 Cambridge/2022/Section 1/ Biology NSAA/ Q# 63 /www.SmashingScience.org/

Q63 | F

Q# 39/ Topic 4 Cambridge/2021/Section 1/ Biology NSAA/ Q# 71 /www.SmashingScience.org/

Q71 | A

Q# 40/ Topic 4 Cambridge/2021/Section 1/ Biology NSAA/ Q# 63 /www.SmashingScience.org/

Q63 | B

Q# 41/ Topic 4 Cambridge/2020sp/Section 1/ Biology NSAA/ Q# 80 /www.SmashingScience.org/
80

The answer is option A.

The question tells us that a cell is surrounded by a dilute glucose solution which has a lower concentration of glucose than the glucose in the cytoplasm of the cell. It also tells us that both water molecules and glucose molecules enter the cell.

There is net movement of water molecules into a cell by osmosis. So we know that the concentration of water molecules outside the cell must be higher than the concentration of water molecules in the cell. Osmosis is a type of passive movement and so will be unaffected by the chemical which inhibits respiration as it does not require energy from the cell to take place. So water molecules will move into the cell.

There is net movement of glucose into the cell against a concentration gradient as the concentration of glucose molecules is lower outside the cell than inside. Glucose molecules must therefore enter by active transport.

Active transport uses energy supplied by respiration. If respiration is inhibited then active transport will no longer take place and glucose molecules will not be able to move into the cell.

Q# 42/ Topic 4 Cambridge/2020sp/Section 1/ Biology NSAA/ Q# 69 /www.SmashingScience.org/

69

The answer is option A.

A change from 0.12 mol dm^{-3} to $0.084 \text{ mol dm}^{-3}$ gives an increase in percentage haemolysis (read graph from right to left) from 2% up to 72%, which is an increase of 70%. The increase is due to the uptake of water through osmosis into the cells, which occurs as a result of the reduction in the concentration of the NaCl solution.

Q# 43/ Topic 4 Cambridge/2020/Section 1/ Biology NSAA/ Q# 71 /www.SmashingScience.org/

Q71 | F

Q# 44/ Topic 4 Cambridge/2018/Section 1/ Biology NSAA/ Q# 62 /www.SmashingScience.org/

62 | G



Q# 45/ Topic 4 Cambridge/2017/Section 1/ Biology NSAA/ Q# 65 /www.SmashingScience.org/

65

C

Q# 46/ Topic 4 Cambridge/2016sp/Section 1/ Biology NSAA/ Q# 63 /www.SmashingScience.org/

63

A

Q# 47/ Topic 4 Cambridge/2016/Section 1/ Biology NSAA/ Q# 56 /www.SmashingScience.org/

56

F

Q# 48/ Topic 5 Cambridge/2024/ESAT/ Biology/ Q# 7 /www.SmashingScience.org/

The answer is: 2 and 3 only.

Bone marrow stem cells will divide by mitosis, rather than meiosis, to produce genetically identical offspring, so statement 1 is incorrect.

Human stem cells, including bone marrow stem cells, are diploid and so contain 46 chromosomes (statement 2 is correct).

Stem cells of the bone marrow are able to differentiate into white blood cells so statement 3 is also correct.

Q# 49/ Topic 5 Cambridge/2024/ESAT/ Biology/ Q# 24 /www.SmashingScience.org/

The answer is: 1 and 3 only.

Mutations are random changes in the DNA sequence of an organism. If this occurs within the sequence of a gene that codes for a protein, then it can change the bases in the triplet sequence of that gene and may alter the amino acids that they code for (statement 1). If the mutation occurs within a gene that codes for an enzyme that is part of an essential cell process, like respiration, then the cell may no longer be able to function correctly and may die (statement 3).

Some mutations do produce positive changes in cells that could be beneficial to the organism. If they occur in a cheek cell instead of a gamete however, they will not be passed on to any offspring of the organism so statement 2 is incorrect.

Q# 50/ Topic 5 Cambridge/2024/ESAT/ Biology/ Q# 1 /www.SmashingScience.org/

The answer is: 4 only.

Statement 1 is incorrect as gamete formation occurs due to meiosis. Both statement 2 and statement 3 are also incorrect. However, they are common misconceptions held by students. Growth of an organism such as a human occurs by mitosis as the number of cells increases. The size of a cell does not increase due to mitosis. Mitosis results in the production of new cells which can be used to replace damaged cells in tissues such as muscles and organs such as skin. However, mitosis cannot repair cells, so statement 3 is incorrect.

Therefore the only correct statement is statement 4 – replacement of skin cells.

Q# 51/ Topic 5 Cambridge/2023/Section 1/ Biology NSAA/ Q# 80 /www.SmashingScience.org/

Q80

D

Q# 52/ Topic 5 Cambridge/2023/Section 1/ Biology NSAA/ Q# 66 /www.SmashingScience.org/

Q66

D

Q# 53/ Topic 5 Cambridge/2021/Section 1/ Biology NSAA/ Q# 75 /www.SmashingScience.org/

Q75

B

Q# 54/ Topic 5 Cambridge/2020sp/Section 1/ Biology NSAA/ Q# 77 /www.SmashingScience.org/

77

The answer is option F.

Mutations are random changes in the DNA sequence of an organism. If this occurs within the sequence of a gene that codes for a protein then it can change the bases in the triplet sequence of that gene and may alter the amino acids that they code for (statement 1). If the mutation occurs within an enzyme that is part of an essential cell process, like respiration, then the cell may no longer be able to function correctly and may die (statement 3).

Some mutations do produce positive changes in cells that could be beneficial to the organism. If they take place in a cheek cell instead of a gamete however, they will not be passed on to any offspring of the organism so statement 2 is incorrect.

66

The answer is option **G**.

Bone marrow stem cells will divide by mitosis, rather than meiosis, to produce genetically identical offspring, so statement 1 is incorrect. Human stem cells, including bone marrow stem cells, are diploid and so contain 46 chromosomes (statement 2 is correct). Stem cells of the bone marrow are able to differentiate into white blood cells so statement 3 is also correct.

61

The answer is option **D**.

Statement 1 is incorrect as gamete formation occurs due to meiosis. Both statement 2 and statement 3 are also incorrect. However, they are common misconceptions held by students. Growth of an organism such as a human occurs by mitosis as the number of cells increases. The size of a cell does not increase due to mitosis. Mitosis results in the production of new cells which can be used to replace damaged cells in tissues such as muscles and organs such as skin. However, mitosis cannot repair cells, so statement 3 is incorrect.

Therefore the only correct statement is statement 4 – replacement of skin cells.

70

G

57

E

58

E

72

F

70

E

66

G

60

F

59

F

55

D

The answer is A.

The genetic code is a triplet code (three bases code for one amino acid). A section of DNA with 420 base pairs can code for 140 amino acids (420 divided by 3).

The DNA contains four bases (adenine, guanine, cytosine and thymine). Adenine binds with thymine and guanine with cytosine. If the DNA contains 42% adenine it will also contain 42% thymine. $42\% \times 2$ is 84%.

This means that 16% are guanine and cytosine together. 16% divided by 2 is 8%.

This DNA therefore contains 42% of adenine, 42% of thymine, 8% of cytosine and 8% of guanine.



Q# 67/ Topic 6 Cambridge/2023/Section 1/ Biology NSAA/ Q# 77 /www.SmashingScience.org/

Q77 | E

Q# 68/ Topic 6 Cambridge/2023/Section 1/ Biology NSAA/ Q# 75 /www.SmashingScience.org/

Q75 | E

Q# 69/ Topic 6 Cambridge/2021/Section 1/ Biology NSAA/ Q# 70 /www.SmashingScience.org/

Q70 | A

Q# 70/ Topic 6 Cambridge/2020sp/Section 1/ Biology NSAA/ Q# 75 /www.SmashingScience.org/ 75

The answer is option A.

The genetic code is a triplet code (three bases code for one amino acid). A section of DNA with 420 base pairs can code for 140 amino acids (420 divided by 3).

The DNA contains four bases (adenine, guanine, cytosine and thymine). Adenine binds with thymine and guanine with cytosine. If the DNA contains 42% adenine it will also contain 42% thymine. $42\% \times 2$ is 84%.

This means that 16% are guanine and cytosine together. 16% divided by 2 is 8%.

This DNA therefore contains 42% of adenine, 42% of thymine, 8% of cytosine and another 8% of guanine.

Q# 71/ Topic 6 Cambridge/2020/Section 1/ Biology NSAA/ Q# 63 /www.SmashingScience.org/

Q63 | G

Q# 72/ Topic 6 Cambridge/2019/Section 1/ Biology NSAA/ Q# 72 /www.SmashingScience.org/

72 | H

Q# 73/ Topic 6 Cambridge/2019/Section 1/ Biology NSAA/ Q# 65 /www.SmashingScience.org/

65 | H

Q# 74/ Topic 6 Cambridge/2019/Section 1/ Biology NSAA/ Q# 57 /www.SmashingScience.org/

57 | C

Q# 75/ Topic 6 Cambridge/2018/Section 1/ Biology NSAA/ Q# 69 /www.SmashingScience.org/

69 | H

Q# 76/ Topic 6 Cambridge/2018/Section 1/ Biology NSAA/ Q# 64 /www.SmashingScience.org/

64 | B

Q# 77/ Topic 6 Cambridge/2018/Section 1/ Biology NSAA/ Q# 63 /www.SmashingScience.org/

63 | A

Q# 78/ Topic 6 Cambridge/2017/Section 1/ Biology NSAA/ Q# 70 /www.SmashingScience.org/

70 | H

Q# 79/ Topic 6 Cambridge/2017/Section 1/ Biology NSAA/ Q# 56 /www.SmashingScience.org/

56 | B

Q# 80/ Topic 6 Cambridge/2016/Section 1/ Biology NSAA/ Q# 72 /www.SmashingScience.org/

72 | E



Q# 81/ Topic 7 Cambridge/2024/ESAT/ Biology/ Q# 9 /www.SmashingScience.org/

The answer is: Carbon dioxide entering the leaves was used to make sugars, some of which were transported by translocation to the roots.

Although carbon dioxide is converted into sugars, this takes place in the photosynthetic parts of plants which are not normally the roots, so the first statement is incorrect. Photosynthesis takes place in leaves.

Although carbon dioxide is taken up and converted into sugars in the leaves, the sugars produced are transported to the roots by translocation and not transpiration. So the third statement is incorrect.

Carbon dioxide does enter the leaves but it is not transported to the roots to be converted into sugars, so the fourth and fifth statements are incorrect.

During photosynthesis carbon dioxide is taken up and used to make sugars. These sugars can then be transported around the plant, including to the roots, by translocation. So the second statement is correct.

Q# 82/ Topic 7 Cambridge/2023/Section 1/ Biology NSAA/ Q# 65 /www.SmashingScience.org/

Q65 | F

Q# 83/ Topic 7 Cambridge/2022/Section 1/ Biology NSAA/ Q# 73 /www.SmashingScience.org/

Q73 | D

Q# 84/ Topic 7 Cambridge/2020sp/Section 1/ Biology NSAA/ Q# 67 /www.SmashingScience.org/

67

The answer is option **B**.

Although carbon dioxide is converted into sugars this takes place in the photosynthetic parts of plants which are not normally the roots so statement **A** is incorrect. Photosynthesis takes place in leaves.

Although carbon dioxide is taken up and converted into sugars in the leaves, the sugars produced are transported to the roots by translocation and not transpiration. So statement **C** is incorrect.

Carbon dioxide does enter the leaves but it is not transported to the roots to be converted into sugars so statements **D** and **E** are incorrect.

During photosynthesis carbon dioxide is taken up and used to make sugars. These sugars can then be transported around the plant, including to the roots, by translocation. So statement **B** is correct.

Q# 85/ Topic 8 Cambridge/2024/ESAT/ Biology/ Q# 23 /www.SmashingScience.org/

The correct answer is row A.

X - At X the ECG trace shows the pattern which triggers the ventricles to contract. The volume of the ventricles is starting to fall. This means blood must be leaving the ventricles and entering the arteries - the pulmonary artery from the right ventricle and the aorta from the left ventricle. This means rows A and C, E and G are correct for this column.

Y - At Y the volume of the ventricles is starting to rise. This means blood must be flowing into the ventricles from the atria. For this to happen the valves between the atria and ventricles must be open. This means rows A, D, F and G are correct for this column.

Z - At Z the ECG trace shows the pattern which triggers the atria to contract. In addition there is a sharp increase in the volume of the ventricles as the atria are now pumping more blood in. This means rows A, C, F and H are correct for this column.

The only row that is correct in all three columns is row A.

Q# 86/ Topic 8 Cambridge/2023/Section 1/ Biology NSAA/ Q# 69 /www.SmashingScience.org/

Q69 | A

Q# 87/ Topic 8 Cambridge/2022/Section 1/ Biology NSAA/ Q# 62 /www.SmashingScience.org/

Q62 | B



The answer is option **D**.

The diagram contains clues to allow the various blood vessels to be identified. Blood vessel 1 has a narrow wall and large lumen, whilst blood vessel 2 has a wide wall and narrow lumen. Veins, such as the vena cava, have a structure as shown by blood vessel 1. Arteries, such as the aorta, have the same structure as shown by blood vessel 2. Any vessel leading directly to vessel 1 is a vein, whilst any vessel leading directly from vessel 2 is an artery.

Urea is produced in the liver and removed by the kidney. Therefore the highest concentration of urea will be found in the tube leading away from the kidney to the bladder, which is tube 5. The name of tube 5 is the ureter, but it is often confused with the urethra which carries urine from the bladder to the outside world.

The blood flowing away from the kidney should have the least urea, since the kidney removes urea from the blood that enters via the renal artery. The renal vein is identified as vessel 3, since it is joined to vessel 1, the vena cava. The vena cava will contain some urea, since as blood passes around the circulatory system, only some of it will enter the kidneys through the renal artery. The rest (containing urea) will travel through other arteries and eventually end up in the vena cava.

Q# 89/ Topic 8 Cambridge/2020/Section 1/ Biology NSAA/ Q# 76 /www.SmashingScience.org/

Q76 | C

Q# 90/ Topic 8 Cambridge/2020/Section 1/ Biology NSAA/ Q# 75 /www.SmashingScience.org/

Q75 | A

Q# 91/ Topic 9 Cambridge/2023/Section 1/ Biology NSAA/ Q# 78 /www.SmashingScience.org/

Q78 | G

Q# 92/ Topic 9 Cambridge/2022/Section 1/ Biology NSAA/ Q# 61 /www.SmashingScience.org/

Q61 | A

Q# 93/ Topic 9 Cambridge/2019/Section 1/ Biology NSAA/ Q# 61 /www.SmashingScience.org/

61 | G

Q# 94/ Topic 9 Cambridge/2019/Section 1/ Biology NSAA/ Q# 60 /www.SmashingScience.org/

60 | G

Q# 95/ Topic 11 Cambridge/2021/Section 1/ Biology NSAA/ Q# 77 /www.SmashingScience.org/

Q77 | C

Q# 96/ Topic 11 Cambridge/2020/Section 1/ Biology NSAA/ Q# 78 /www.SmashingScience.org/

Q78 | F

Q# 97/ Topic 12 Cambridge/2024/ESAT/ Biology/ Q# 20 /www.SmashingScience.org/

The answer is: 1 and 3 only.

This question is much more straightforward if all concentrations are converted into the same units.

<i>location</i>	<i>concentration of potassium ions</i>
bacterial cell cytoplasm	30 mmol dm ⁻³
mammalian blood plasma	4000 μmol dm ⁻³ = 4 mmol dm ⁻³
mammalian heart cell cytoplasm	1.0 × 10 ² mmol dm ⁻³ = 100 mmol dm ⁻³
sea water	3.0 × 10 ⁴ μmol dm ⁻³ = 30 000 μmol dm ⁻³ = 30 mmol dm ⁻³
yeast cell cytoplasm	300 mmol dm ⁻³

A mammalian heart cell needs energy from respiration in order to obtain more potassium ions from blood plasma (1). The concentration of potassium ions inside a heart cell is 100 mmol dm⁻³ and in blood plasma is 4 mmol dm⁻³. In order for the heart cell to take up more potassium ions, it would need to use active transport to move the ions against the concentration gradient. This requires energy from respiration, so this statement is correct.

If a yeast cell is placed in sea water then it will lose potassium ions by osmosis (2). This is incorrect. The only substance that can move by osmosis is water. The potassium ions may well diffuse down a concentration gradient from the yeast cell (concentration 300 mmol dm⁻³) to the sea water (concentration 30 mmol dm⁻³) but this would be by diffusion not osmosis.

There is no concentration gradient for potassium ions between a bacterial cell and sea water (3). The concentration of potassium ions in both the bacterial cell and the sea water is 30 mmol dm⁻³ so there would be no concentration gradient between the two. This statement is correct.

The correct answer is: 1 and 3 only.

Q# 98/ Topic 12 Cambridge/2024/ESAT/ Biology/ Q# 2 /www.SmashingScience.org/

The answer is: Both anaerobic and aerobic respiration are taking place.

As oxygen is being supplied and used, aerobic respiration is occurring in these muscle cells. However, as the oxygen demand between 0 and 11 minutes is greater than the supply, as shown by the higher position of the oxygen demand line on the graph, the muscle cells are also carrying out anaerobic respiration.

Q# 99/ Topic 12 Cambridge/2023/Section 1/ Biology NSAA/ Q# 72 /www.SmashingScience.org/

Q72 | A

Q# 100/ Topic 12 Cambridge/2021/Section 1/ Biology NSAA/ Q# 72 /www.SmashingScience.org/

Q72 | D

Q# 101/ Topic 12 Cambridge/2021/Section 1/ Biology NSAA/ Q# 68 /www.SmashingScience.org/

Q68 | G

Q# 102/ Topic 12 Cambridge/2020sp/Section 1/ Biology NSAA/ Q# 74 /www.SmashingScience.org/
74

The answer is option H.

Process 1 is photosynthesis and therefore should not feature in any answers. For carbon to be incorporated into animals and decomposers, digestion of carbon-rich compounds must initially occur (processes 2 and 3). Respiration can release carbon into the air as CO₂ which is illustrated by process 4.

Q# 103/ Topic 12 Cambridge/2020sp/Section 1/ Biology NSAA/ Q# 62 /www.SmashingScience.org/
62

The answer is option **D**.

As oxygen is being supplied and used, aerobic respiration is occurring in these muscle cells. However, as the oxygen demand between 0 and 11 minutes is greater than the supply, as shown by the higher position of the oxygen demand line on the graph, the muscle cells are also carrying out anaerobic respiration.

Q# 104/ Topic 12 Cambridge/2019/Section 1/ Biology NSAA/ Q# 69 /www.SmashingScience.org/

69 | A

Q# 105/ Topic 12 Cambridge/2017/Section 1/ Biology NSAA/ Q# 55 /www.SmashingScience.org/

55 | A

Q# 106/ Topic 12 Cambridge/2016sp/Section 1/ Biology NSAA/ Q# 67 /www.SmashingScience.org/

67 | H

Q# 107/ Topic 12 Cambridge/2016sp/Section 1/ Biology NSAA/ Q# 56 /www.SmashingScience.org/

56 | D

Q# 108/ Topic 12 Cambridge/2016/Section 1/ Biology NSAA/ Q# 70 /www.SmashingScience.org/

70 | C

Q# 109/ Topic 12 Cambridge/2016/Section 1/ Biology NSAA/ Q# 68 /www.SmashingScience.org/

68 | B

Q# 110/ Topic 13 Cambridge/2024/ESAT/ Biology/ Q# 19 /www.SmashingScience.org/

The answer is **H**.

Process 1 is photosynthesis and therefore should not feature in any answers. For carbon to be incorporated into animals and decomposers, digestion of carbon-rich compounds must initially occur (processes 2 and 3). Respiration can release carbon into the air as CO_2 which is illustrated by process 4.

Q# 111/ Topic 13 Cambridge/2024/ESAT/ Biology/ Q# 14 /www.SmashingScience.org/

The answer is row **H**.

The rate of gas production is given in the question as $2\pi \text{ mm}^3$ per minute and the capillary diameter as 2 mm. The question also states that the experiment ran for 5 minutes so the total volume of gas collected was $5 \times 2\pi = 10\pi \text{ mm}^3$. To calculate the distance moved by the bubble of gas from this value you must use the equation $\pi r^2 h$, where r is the radius of the capillary tube and h is the distance moved by the gas bubble. The diameter of the capillary tube is 2 mm so the radius is 1 mm. This means that $\pi \times 1^2 \times \text{distance moved} = 10\pi \text{ mm}^3$, so the distance moved by the bubble is 10 mm.

Photosynthesis is an endothermic reaction so it must take in energy. In the case of energy this is in the form of light.

If the lamp was moved further away from the pondweed, it would decrease the light intensity shining on the plant. This would decrease the rate of photosynthesis, making the gas bubble move more slowly than the original experiment. As the gas is released from the plant it moves along the tube from left to right.

This makes the correct option **H**.

Q# 112/ Topic 13 Cambridge/2023/Section 1/ Biology NSAA/ Q# 73 /www.SmashingScience.org/

Q73 | G

Q# 113/ Topic 13 Cambridge/2023/Section 1/ Biology NSAA/ Q# 62 /www.SmashingScience.org/

Q62 | B

Q# 114/ Topic 13 Cambridge/2022/Section 1/ Biology NSAA/ Q# 79 /www.SmashingScience.org/

Q79 | D



Q# 115/ Topic 13 Cambridge/2022/Section 1/ Biology NSAA/ Q# 75 /www.SmashingScience.org/

Q75 | C

Q# 116/ Topic 13 Cambridge/2020sp/Section 1/ Biology NSAA/ Q# 64 /www.SmashingScience.org/

64

The answer is option E.

The main factors affecting the rate of photosynthesis are light intensity, temperature and carbon dioxide concentration. Any change in the level of a factor will affect the rate of reaction and the process will be limited by the factor which is in the shortest supply.

In the case of temperature, the rate of reaction will increase until the optimum temperature for the enzymes controlling the reaction is reached, as long as the other factors are present in sufficient amounts. Therefore statement 1 is correct. After this point the enzymes start to become denatured and no longer work, so statement 2 is correct. An increase in temperature produces an increase in kinetic energy and, up to a temperature of 22 °C the rate of photosynthesis also increases. However temperature does not increase the rate across the whole of the range studied as after the optimum temperature has been reached, the rate of photosynthesis decreases. Therefore statement 3 is incorrect.

Q# 117/ Topic 13 Cambridge/2020/Section 1/ Biology NSAA/ Q# 73 /www.SmashingScience.org/

Q73 | H

Q# 118/ Topic 13 Cambridge/2019/Section 1/ Biology NSAA/ Q# 63 /www.SmashingScience.org/

63 | A

Q# 119/ Topic 13 Cambridge/2018/Section 1/ Biology NSAA/ Q# 67 /www.SmashingScience.org/

67 | A

Q# 120/ Topic 13 Cambridge/2017/Section 1/ Biology NSAA/ Q# 67 /www.SmashingScience.org/

67 | F

Q# 121/ Topic 13 Cambridge/2016sp/Section 1/ Biology NSAA/ Q# 58 /www.SmashingScience.org/

58 | D

Q# 122/ Topic 13 Cambridge/2016/Section 1/ Biology NSAA/ Q# 61 /www.SmashingScience.org/

61 | B

Q# 123/ Topic 14 Cambridge/2024/ESAT/ Biology/ Q# 16 /www.SmashingScience.org/

The answer is: 1 only.

Statement 1 is correct. Body temperature is controlled by homeostasis using negative feedback. The fall in body temperature could have been brought about by increased sweat production, leading to the cooling of the skin by increased evaporation.

Statement 2 is incorrect. Whilst the thermoregulatory centre in the brain is responsible for regulating body temperature, a fall in body temperature as shown between X and Y on the graph will only occur if the hairs on the skin lie flat. When the body temperature is too low, the hairs on the skin are raised in order to trap an insulating layer of air, in order to reduce heat loss.

Statement 3 is incorrect. Whilst the thermoregulatory centre in the brain is responsible for regulating body temperature, a fall in body temperature as shown between X and Y on the graph will only occur if more blood flows to the surface of the skin, so that heat from the blood can be lost to the environment.

Q# 124/ Topic 14 Cambridge/2024/ESAT/ Biology/ Q# 15 /www.SmashingScience.org/

The answer is D.

The diagram contains clues to allow the various blood vessels to be identified. Blood vessel 1 has a narrow wall and large lumen, whilst blood vessel 2 has a wide wall and narrow lumen. Veins, such as the vena cava, have a structure as shown by blood vessel 1. Arteries, such as the aorta, have the same structure as shown by blood vessel 2. Any vessel leading directly to vessel 1 is a vein, whilst any vessel leading directly from vessel 2 is an artery.

Urea is produced in the liver and removed by the kidney. Therefore the highest concentration of urea will be found in the tube leading away from the kidney to the bladder, which is tube 5. The name of tube 5 is the ureter, but it is often confused with the urethra which carries urine from the bladder to the outside world.

The blood flowing away from the kidney should have the least urea, since the kidney removes urea from the blood that enters via the renal artery. The renal vein is identified as vessel 3, since it is joined to vessel 1, the vena cava. The vena cava will contain some urea, since as blood passes around the circulatory system, only some of it will enter the kidneys through the renal artery. The rest (containing urea) will travel through other arteries and eventually end up in the vena cava.

Q# 125/ Topic 14 Cambridge/2023/Section 1/ Biology NSAA/ Q# 70 /www.SmashingScience.org/

Q70 | **E**

Q# 126/ Topic 14 Cambridge/2022/Section 1/ Biology NSAA/ Q# 72 /www.SmashingScience.org/

Q72 | **B**

Q# 127/ Topic 14 Cambridge/2021/Section 1/ Biology NSAA/ Q# 64 /www.SmashingScience.org/

Q64 | **D**

Q# 128/ Topic 14 Cambridge/2020sp/Section 1/ Biology NSAA/ Q# 71 /www.SmashingScience.org/

71

The answer is option **B**.

Statement 1 is correct. Body temperature is controlled by homeostasis using negative feedback. The fall in body temperature could have been brought about by increased sweat production, leading to the cooling of the skin by increased evaporation.

Statement 2 is incorrect. Whilst the thermoregulatory centre in the brain is responsible for regulating body temperature, a fall in body temperature as shown between X and Y on the graph will only occur if the hairs on the skin lie flat. When the body temperature is too low, the hairs on the skin are raised in order to trap an insulating layer of air, in order to reduce heat loss.

Statement 3 is incorrect. Whilst the thermoregulatory centre in the brain is responsible for regulating body temperature, a fall in body temperature as shown between X and Y on the graph will only occur if more blood flows to the surface of the skin, so that heat from the blood can be lost to the environment.

Q# 129/ Topic 14 Cambridge/2020/Section 1/ Biology NSAA/ Q# 67 /www.SmashingScience.org/

Q67 | **F**

Q# 130/ Topic 15 Cambridge/2023/Section 1/ Biology NSAA/ Q# 79 /www.SmashingScience.org/

Q79 | **E**

Q# 131/ Topic 15 Cambridge/2022/Section 1/ Biology NSAA/ Q# 66 /www.SmashingScience.org/

Q66 | **E**

Q# 132/ Topic 15 Cambridge/2022/Section 1/ Biology NSAA/ Q# 64 /www.SmashingScience.org/

Q64 | **B**

Q# 133/ Topic 15 Cambridge/2019/Section 1/ Biology NSAA/ Q# 56 /www.SmashingScience.org/

56 | **E**

Q# 134/ Topic 15 Cambridge/2018/Section 1/ Biology NSAA/ Q# 61 /www.SmashingScience.org/

61	H
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Q# 135/ Topic 15 Cambridge/2017/Section 1/ Biology NSAA/ Q# 69 /www.SmashingScience.org/

69	A
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Q# 136/ Topic 15 Cambridge/2017/Section 1/ Biology NSAA/ Q# 63 /www.SmashingScience.org/

63	G
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Q# 137/ Topic 15 Cambridge/2016sp/Section 1/ Biology NSAA/ Q# 64 /www.SmashingScience.org/

64	H
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Q# 138/ Topic 15 Cambridge/2016/Section 1/ Biology NSAA/ Q# 63 /www.SmashingScience.org/

63	H
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Q# 139/ Topic 16 Cambridge/2024/ESAT/ Biology/ Q# 6 /www.SmashingScience.org/

The answer is: 2 and 3 only.

Statement 1 is incorrect as at position 21 there are three chromosomes rather than two. This is an example of a chromosome mutation and leads to Down's syndrome.

Statement 2 is correct as the 23rd pair of chromosomes are the sex chromosomes and as they are XY this means the cell has been donated by a male.

White blood cells are diploid body cells and so they contain two copies of each autosome (and in the case of this particular cell, three copies of chromosome 21) with two sex chromosomes as shown in the karyogram, so statement 3 is also correct.

Q# 140/ Topic 16 Cambridge/2024/ESAT/ Biology/ Q# 4 /www.SmashingScience.org/

The answer is C.

The genotype of the female brown rabbits is bb.

A homozygous black rabbit is BB. All of its offspring when crossed with a brown rabbit will be Bb and will be black.

A heterozygous black rabbit is Bb. When crossed with a brown rabbit, the expected proportion of brown (bb) offspring is 0.5, with the other 0.5 being black (Bb).

If both the male rabbits are heterozygous, the expectation is that half the offspring from each mating will be brown, so the expected proportion of brown rabbits born from the two matings is 0.50.

If only one of the male rabbits is heterozygous, the other must be homozygous. The expected proportion of brown offspring of the heterozygous rabbit is 0.5, whilst all of the offspring of the homozygous rabbit will be black. The expected proportion of brown rabbits born from the two matings if only one of the male rabbits is heterozygous, is therefore 0.25.

Q# 141/ Topic 16 Cambridge/2024/ESAT/ Biology/ Q# 25 /www.SmashingScience.org/

The answer is: 1, 2 and 3.

Using the information in the question, as the condition is caused by at least one allele it must be a dominant allele (statement 1). Therefore, although U is likely to be heterozygous for the allele, she will have the condition because the condition is dominant.

For U to show the condition she must have received the allele for this condition from one of her parents and this would be T as he shows the condition (statement 2). In this case U would be heterozygous.

Although U's mother does not show the condition, a mutation could occur in the egg that is fertilised by T's sperm (statement 3). In this case U would be homozygous for the condition if she had also received the allele from T, or heterozygous if the only copy of the allele for the condition was received as a result of the mutation.

Q# 142/ Topic 16 Cambridge/2024/ESAT/ Biology/ Q# 18 /www.SmashingScience.org/

The answer is G.

The ratio of X : A in columns 1 and 2 is 0.5 : 1 which makes the flies male, irrespective of the presence or absence of the Y chromosome. The ratio of X : A in columns 3, 4 and 5 is 1 : 1 which makes the flies female, irrespective of the presence or absence of the Y chromosome.

Q# 143/ Topic 16 Cambridge/2024/ESAT/ Biology/ Q# 13 /www.SmashingScience.org/

The answer is: 1 only.

In areas where there is no malaria, there is no advantage to maintaining the m allele and indeed there is a disadvantage as stated in the question (sickle cell anaemia can be fatal). Therefore, the frequency of the m allele will decrease, so statement 1 is correct.

In areas with malaria, it will not be only heterozygous individuals who are able to pass on their alleles. Individuals who are homozygous dominant (MM) are susceptible to malaria infection but this does not mean they will become infected, so they could still reproduce and pass on their alleles. Individuals who are mm may also be able to reproduce and pass on their alleles so statement 2 is incorrect.

Statement 3 is also incorrect as mutations occur randomly and lead to variation. In this case, the m allele would already be present. The presence of malaria acts as the natural selection mechanism that tends to select those individuals with one m allele rather than causing the mutation to occur.

Q# 144/ Topic 16 Cambridge/2024/ESAT/ Biology/ Q# 10 /www.SmashingScience.org/

The answer is 7.

The two females with attached ear lobes are homozygous recessive. The female in the first generation must be heterozygous, as she has the dominant phenotype, but must have inherited the recessive allele from her mother (who is homozygous recessive). The male in the first generation must also be heterozygous, because the female with attached earlobes in the second generation must have inherited a recessive allele from him, but he has the dominant phenotype. The male parent and the people in the second generation who have unattached ear lobes could be either heterozygous or homozygous dominant. So the maximum possible number of heterozygous individuals is 7.

Q# 145/ Topic 16 Cambridge/2023/Section 1/ Biology NSAA/ Q# 76 /www.SmashingScience.org/

Q76 | B

Q# 146/ Topic 16 Cambridge/2023/Section 1/ Biology NSAA/ Q# 68 /www.SmashingScience.org/

Q68 | F

Q# 147/ Topic 16 Cambridge/2022/Section 1/ Biology NSAA/ Q# 80 /www.SmashingScience.org/

Q80 | C

Q# 148/ Topic 16 Cambridge/2022/Section 1/ Biology NSAA/ Q# 78 /www.SmashingScience.org/

Q78 | G

Q# 149/ Topic 16 Cambridge/2022/Section 1/ Biology NSAA/ Q# 77 /www.SmashingScience.org/

Q77 | A

Q# 150/ Topic 16 Cambridge/2022/Section 1/ Biology NSAA/ Q# 67 /www.SmashingScience.org/

Q67 | G

Q# 151/ Topic 16 Cambridge/2021/Section 1/ Biology NSAA/ Q# 79 /www.SmashingScience.org/

Q79 | A

Q# 152/ Topic 16 Cambridge/2021/Section 1/ Biology NSAA/ Q# 78 /www.SmashingScience.org/

Q78 | A

Q# 153/ Topic 16 Cambridge/2021/Section 1/ Biology NSAA/ Q# 74 /www.SmashingScience.org/

Q74 | C

Q# 154/ Topic 16 Cambridge/2021/Section 1/ Biology NSAA/ Q# 69 /www.SmashingScience.org/

Q69 | B

Q# 155/ Topic 16 Cambridge/2021/Section 1/ Biology NSAA/ Q# 65 /www.SmashingScience.org/

Q65 | C



Q# 156/ Topic 16 Cambridge/2020sp/Section 1/ Biology NSAA/ Q# 78 /www.SmashingScience.org/
78

The answer is option **E**.

Using the information in the question, as the condition is caused by at least one allele it must be a dominant allele (statement 1). Therefore a person with the condition can be heterozygous or homozygous. For U to show the condition she must have received the allele for this condition from one of her parents and this would be T as he shows the condition (statement 2). In this case U would be heterozygous. Although U's mother does not show the condition a mutation could occur in the egg that is fertilised by T's sperm (statement 3). In this case U would be homozygous for the condition.

Q# 157/ Topic 16 Cambridge/2020sp/Section 1/ Biology NSAA/ Q# 73 /www.SmashingScience.org/
73

The answer is option **G**.

The ratio of X:A in columns 1 and 2 is 0.5 : 1 which makes the flies male, irrespective of the presence or absence of the Y chromosome. The ratio of X:A in columns 3, 4 and 5 is 1 : 1 which makes the flies female, irrespective of the presence or absence of the Y chromosome.

Q# 158/ Topic 16 Cambridge/2020sp/Section 1/ Biology NSAA/ Q# 68 /www.SmashingScience.org/
68

The answer is option **F**.

The two females with attached ear lobes are homozygous recessive. The female in the first generation must be heterozygous, as she has the dominant phenotype, but must have inherited the recessive allele from her mother (who is homozygous recessive). The male parent, the male in the first generation, and the people in the second generation who have unattached ear lobes could be either heterozygous or homozygous dominant. So the maximum possible number of heterozygous individuals is 7.

Q# 159/ Topic 16 Cambridge/2020sp/Section 1/ Biology NSAA/ Q# 65 /www.SmashingScience.org/
65

The answer is option **G**.

Statement 1 is incorrect as at position 21 there are three chromosomes rather than two. As such, this is an example of a chromosome mutation and leads to Down's syndrome. Statement 2 is correct as the 23rd pair of chromosomes are the sex chromosomes and as they are XY this means the cell has been donated by a male. White blood cells are diploid body cells and so they contain two copies of each chromosome with two sex chromosomes as shown in the karyogram, so statement 3 is also correct.

Q# 160/ Topic 16 Cambridge/2020/Section 1/ Biology NSAA/ Q# 80 /www.SmashingScience.org/

Q80 | **F**

Q# 161/ Topic 16 Cambridge/2020/Section 1/ Biology NSAA/ Q# 79 /www.SmashingScience.org/

Q79 | **C**

Q# 162/ Topic 16 Cambridge/2020/Section 1/ Biology NSAA/ Q# 70 /www.SmashingScience.org/

Q70 | **B**

Q# 163/ Topic 16 Cambridge/2020/Section 1/ Biology NSAA/ Q# 65 /www.SmashingScience.org/

Q65 | **F**

Q# 164/ Topic 16 Cambridge/2020/Section 1/ Biology NSAA/ Q# 61 /www.SmashingScience.org/

Q61 | **H**



Q# 165/ Topic 16 Cambridge/2019/Section 1/ Biology NSAA/ Q# 70 /www.SmashingScience.org/

70 | H

Q# 166/ Topic 16 Cambridge/2019/Section 1/ Biology NSAA/ Q# 68 /www.SmashingScience.org/

68 | E

Q# 167/ Topic 16 Cambridge/2019/Section 1/ Biology NSAA/ Q# 66 /www.SmashingScience.org/

66 | B

Q# 168/ Topic 16 Cambridge/2018/Section 1/ Biology NSAA/ Q# 72 /www.SmashingScience.org/

72	B
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Q# 169/ Topic 16 Cambridge/2018/Section 1/ Biology NSAA/ Q# 65 /www.SmashingScience.org/

65	F
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Q# 170/ Topic 16 Cambridge/2018/Section 1/ Biology NSAA/ Q# 60 /www.SmashingScience.org/

60	E
----	---

Q# 171/ Topic 16 Cambridge/2018/Section 1/ Biology NSAA/ Q# 59 /www.SmashingScience.org/

59	E
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Q# 172/ Topic 16 Cambridge/2018/Section 1/ Biology NSAA/ Q# 56 /www.SmashingScience.org/

56	D
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Q# 173/ Topic 16 Cambridge/2017/Section 1/ Biology NSAA/ Q# 72 /www.SmashingScience.org/

72	F
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Q# 174/ Topic 16 Cambridge/2017/Section 1/ Biology NSAA/ Q# 66 /www.SmashingScience.org/

66	C
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Q# 175/ Topic 16 Cambridge/2017/Section 1/ Biology NSAA/ Q# 64 /www.SmashingScience.org/

64	B
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Q# 176/ Topic 16 Cambridge/2016sp/Section 1/ Biology NSAA/ Q# 71 /www.SmashingScience.org/

71	D
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Q# 177/ Topic 16 Cambridge/2016sp/Section 1/ Biology NSAA/ Q# 62 /www.SmashingScience.org/

62	F
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Q# 178/ Topic 16 Cambridge/2016/Section 1/ Biology NSAA/ Q# 69 /www.SmashingScience.org/

69	D
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Q# 179/ Topic 16 Cambridge/2016/Section 1/ Biology NSAA/ Q# 67 /www.SmashingScience.org/

67	D
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Q# 180/ Topic 16 Cambridge/2016/Section 1/ Biology NSAA/ Q# 65 /www.SmashingScience.org/

65	G
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Q# 181/ Topic 16 Cambridge/2016/Section 1/ Biology NSAA/ Q# 59 /www.SmashingScience.org/

59	E
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Q# 182/ Topic 17 Cambridge/2024/ESAT/ Biology/ Q# 3 /www.SmashingScience.org/

The answer is: 1, 2, 3 and 4.

Competition for limiting resources can occur both within a species (intraspecific – statement 1) and between species (interspecific – statement 2). Likewise, natural selection can lead to evolution due to individuals with advantageous adaptations being more likely to survive and pass on their alleles, thus passing on the advantageous adaptations to their offspring (statement 3). For a species that competes less well, natural selection may lead to extinction (statement 4). Therefore all four statements are correct.

Q# 183/ Topic 17 Cambridge/2022/Section 1/ Biology NSAA/ Q# 68 /www.SmashingScience.org/

Q68 | **G**

Q# 184/ Topic 17 Cambridge/2021/Section 1/ Biology NSAA/ Q# 61 /www.SmashingScience.org/

Q61 | **F**

Q# 185/ Topic 17 Cambridge/2020sp/Section 1/ Biology NSAA/ Q# 63 /www.SmashingScience.org/ 63

The answer is option **F**.

Competition for limiting resources can occur both within a species (intraspecific – statement 1) and between species (interspecific – statement 2). Likewise, natural selection can lead to evolution due to individuals with advantageous adaptations being more likely to survive and pass on their alleles, thus passing on the advantageous adaptations to their offspring (statement 3). For a species that competes less well, natural selection may lead to extinction (statement 4). Therefore all four statements are correct.

Q# 186/ Topic 17 Cambridge/2018/Section 1/ Biology NSAA/ Q# 71 /www.SmashingScience.org/

71 | **F**

Q# 187/ Topic 17 Cambridge/2016sp/Section 1/ Biology NSAA/ Q# 57 /www.SmashingScience.org/

57 | **F**

Q# 188/ Topic 17 Cambridge/2016/Section 1/ Biology NSAA/ Q# 55 /www.SmashingScience.org/

55 | **C**

Q# 189/ Topic 18 Cambridge/2024/ESAT/ Biology/ Q# 17 /www.SmashingScience.org/

The answer is: 2 and 4 only.

In order to interpret this data correctly you need to ensure that you understand what is represented by the graph.

The x-axis shows the years studied from 1959 to 2008.

The left-hand vertical axis represents the number of wolves, with a range from 0 to just over 50.

The right-hand vertical axis represents the number of moose, with a range from 0 to just under 2500.

Trend 1 is quickly determined to be incorrect, since from 1959 to 1965, overall both the wolf and moose populations are increasing. Additionally, with no knowledge of what has happened before 1959 it cannot be said that there has been an increase in the wolf population as there was an earlier increase in moose population.

Trend 2 is correct. You need to remember that the two vertical scales are different. Reading from the graph, the maximum wolf population is 50, whilst the minimum moose population is about 400.

Trend 3 is incorrect. Whilst the point plotted for wolves is higher than that for moose in 1965, you need to remember that the two vertical scales are different. There are about 30 wolves but there are about 750 moose.

Trend 4 is correct. When wolf populations are low on the graph, such as from 1968 to 1973 and from 1982 to 1995, there is a corresponding increase in the size of the moose population.

Q# 190/ Topic 18 Cambridge/2023/Section 1/ Biology NSAA/ Q# 63 /www.SmashingScience.org/

Q63 | **B**

Q# 191/ Topic 18 Cambridge/2023/Section 1/ Biology NSAA/ Q# 61 /www.SmashingScience.org/

Q61 | A

Q# 192/ Topic 18 Cambridge/2022/Section 1/ Biology NSAA/ Q# 70 /www.SmashingScience.org/

Q70 | F

Q# 193/ Topic 18 Cambridge/2022/Section 1/ Biology NSAA/ Q# 69 /www.SmashingScience.org/

Q69 | D

Q# 194/ Topic 18 Cambridge/2022/Section 1/ Biology NSAA/ Q# 65 /www.SmashingScience.org/

Q65 | D

Q# 195/ Topic 18 Cambridge/2021/Section 1/ Biology NSAA/ Q# 80 /www.SmashingScience.org/

Q80 | D

Q# 196/ Topic 18 Cambridge/2021/Section 1/ Biology NSAA/ Q# 66 /www.SmashingScience.org/

Q66 | H

Q# 197/ Topic 18 Cambridge/2020sp/Section 1/ Biology NSAA/ Q# 72 /www.SmashingScience.org/
72

The answer is option D.

In order to interpret this data correctly you need to ensure that you understand what is represented by the graph.

The x-axis shows the years studied from 1959 to 2008.

The left-hand vertical axis represents the number of wolves, with a range from 0 to just over 50.

The right-hand vertical axis represents the number of moose, with a range from 0 to just under 2500.

Trend 1 is quickly determined to be incorrect, since from 1959 to 1965, overall both the wolf and moose populations are increasing. Additionally, with no knowledge of what has happened before 1959 it cannot be said that there has been an increase in the wolf population as there was an earlier increase in moose population.

Trend 2 is correct. You need to remember that the two vertical scales are different. Reading from the graph, the maximum wolf population is 50, whilst the minimum moose population is about 400.

Trend 3 is incorrect. Whilst the point plotted for wolves is higher than that for moose in 1965, you need to remember that the two vertical scales are different. There are about 30 wolves but there are about 750 moose.

Trend 4 is correct. When wolf populations are low on the graph, such as from 1968 to 1973 and from 1982 to 1995, there is a corresponding increase in the size of the moose population.

Q# 198/ Topic 18 Cambridge/2020/Section 1/ Biology NSAA/ Q# 74 /www.SmashingScience.org/

Q74 | A

Q# 199/ Topic 18 Cambridge/2020/Section 1/ Biology NSAA/ Q# 69 /www.SmashingScience.org/

Q69 | F

Q# 200/ Topic 18 Cambridge/2019/Section 1/ Biology NSAA/ Q# 59 /www.SmashingScience.org/

59 | D

Q# 201/ Topic 18 Cambridge/2019/Section 1/ Biology NSAA/ Q# 58 /www.SmashingScience.org/

58 | C



Q# 202/ Topic 18 Cambridge/2018/Section 1/ Biology NSAA/ Q# 58 /www.SmashingScience.org/

58

E

Q# 203/ Topic 18 Cambridge/2018/Section 1/ Biology NSAA/ Q# 55 /www.SmashingScience.org/

55

F

Q# 204/ Topic 18 Cambridge/2017/Section 1/ Biology NSAA/ Q# 71 /www.SmashingScience.org/

71

C

Q# 205/ Topic 18 Cambridge/2017/Section 1/ Biology NSAA/ Q# 61 /www.SmashingScience.org/

61

B

Q# 206/ Topic 18 Cambridge/2017/Section 1/ Biology NSAA/ Q# 59 /www.SmashingScience.org/

59

A

Q# 207/ Topic 18 Cambridge/2017/Section 1/ Biology NSAA/ Q# 57 /www.SmashingScience.org/

57

C

Q# 208/ Topic 18 Cambridge/2016sp/Section 1/ Biology NSAA/ Q# 65 /www.SmashingScience.org/

65

D

Q# 209/ Topic 18 Cambridge/2016sp/Section 1/ Biology NSAA/ Q# 61 /www.SmashingScience.org/

61

C

Q# 210/ Topic 18 Cambridge/2016/Section 1/ Biology NSAA/ Q# 66 /www.SmashingScience.org/

66

E

Q# 211/ Topic 19 Cambridge/2024/ESAT/ Biology/ Q# 22 /www.SmashingScience.org/

The answer is: 1 and 3 only.

In order to genetically modify bacteria to produce human insulin you need to cut out the DNA coding for human insulin from a normal, healthy human's DNA. A special enzyme is used to cut the DNA. Therefore statement 1 is correct.

This DNA is then inserted into the DNA of a bacterium. However, bacteria do not have a nucleus, so statement 2 is incorrect.

The modified bacteria have to be cultured. This means that they are grown in a fermenter so that large numbers of bacteria are produced. Therefore statement 3 is correct.

The bacteria are used to produce human insulin, which is extracted from them and purified. This insulin is then used to treat diabetics. Therefore, statement 4 is incorrect, since bacteria are not injected into humans with diabetes.

Q# 212/ Topic 19 Cambridge/2020sp/Section 1/ Biology NSAA/ Q# 76 /www.SmashingScience.org/

76

The answer is option B.

In order to genetically modify bacteria to produce human insulin you need to cut out the DNA coding for human insulin from a normal, healthy human's DNA. A special enzyme is used to cut the DNA. Therefore statement 1 is correct.

This DNA is then inserted into the DNA of a bacterium. Bacteria do not have a nucleus, so statement 2 is incorrect.

The modified bacteria have to be cultured. This means that they are grown in a fermenter so that large numbers of bacteria are produced. Therefore statement 3 is correct.

The bacteria are used to produce human insulin, which is extracted from them and purified. This insulin is then used to treat diabetics. Therefore, statement 4 is incorrect, since bacteria are not injected into humans with diabetes.

Q# 213/ Topic 19 Cambridge/2020/Section 1/ Biology NSAA/ Q# 68 /www.SmashingScience.org/

Q68	E
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Q# 214/ Topic 19 Cambridge/2019/Section 1/ Biology NSAA/ Q# 62 /www.SmashingScience.org/

62	D
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Q# 215/ Topic 19 Cambridge/2018/Section 1/ Biology NSAA/ Q# 68 /www.SmashingScience.org/

68	C
----	---

Q# 216/ Topic 19 Cambridge/2018/Section 1/ Biology NSAA/ Q# 66 /www.SmashingScience.org/

66	E
----	---

Q# 217/ Topic 19 Cambridge/2016sp/Section 1/ Biology NSAA/ Q# 69 /www.SmashingScience.org/

69	B
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W2Section 2 Mark Scheme

Q# 218/ Section 2 Topic 1 Cambridge/2022/Section 2/ BIOLOGY NSAA/ www.SmashingScience.org

Q47	E
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Q# 219/ Section 2 Topic 1 Cambridge/2022/Section 2/ BIOLOGY NSAA/ www.SmashingScience.org

Q48	H
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Q# 220/ Section 2 Topic 1 Cambridge/2021/Section 2/ BIOLOGY NSAA/ www.SmashingScience.org

Q52	A
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Q# 221/ Section 2 Topic 1 Cambridge/2020/Section 2/ BIOLOGY NSAA/ www.SmashingScience.org

Q53	F
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Q# 222/ Section 2 Topic 1 Cambridge/2018/Section 2/ BIOLOGY NSAA/ www.SmashingScience.org

Biology Admissions Assessment Answers 2018

B1

- a) Sketch a simple diagram of a eukaryotic cell, and label the locations where DNA transcription and RNA translation take place (2 Marks)

A. Students should draw a simple diagram, with transcription labelled in the nucleus (1 Mark) and translation on free or attached ribosomes in the cytoplasm (1 Mark)

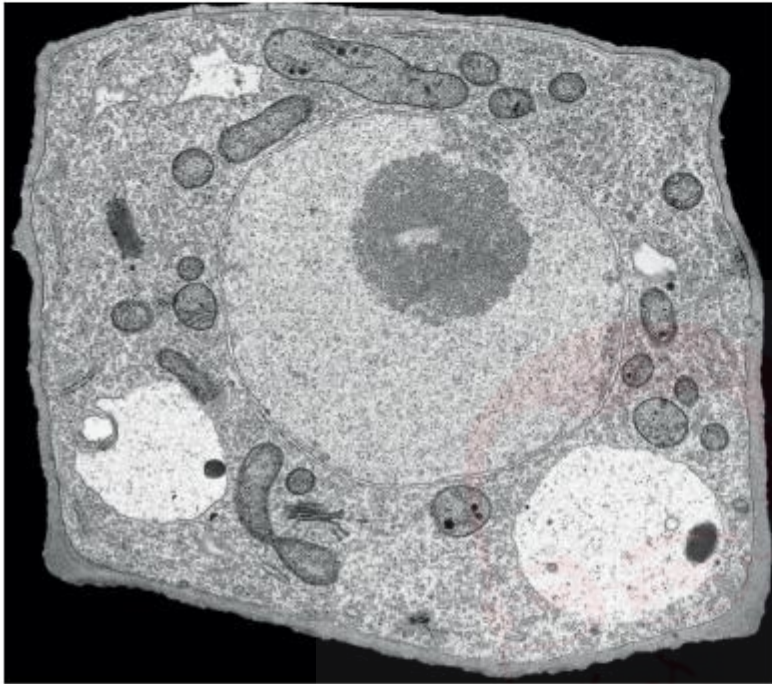
Biology

Question B1

a) Identify the types of cells that can be seen in Fig. (i) and (ii).

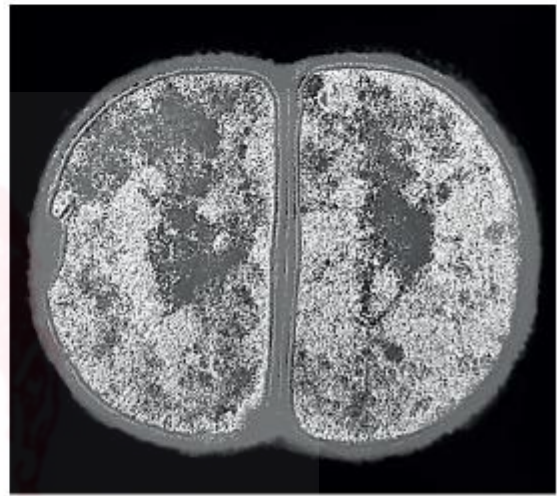
[2 marks]

Fig. (i)



20 μm

Fig. (ii)



0.5 μm

Answer:

- (i) Eukaryote (1/2 mark), Plant cell (1 mark)
(ii) Prokaryote (1/2 mark), Bacterium (1 mark)

b) Why was an electron microscope used to create these images?

[1 mark]

Answer: The structural features are too small to see with the naked eye, but electron microscopes give greater resolution of smaller objects (only 1/2 mark given if resolution is not mentioned)

c) Assume that the scale bar below each image is 3 cm long.

Estimate the magnification of each image.

[2 marks]

Answer:

(i) $= 30,000/20 = 1,500x$

.....

(ii) $= 30,000/0.5 = 60,000x$

.....

d) Discuss the evolutionary order of appearance of the mitochondrion, chloroplast and ribosome, explaining your reasoning.

[3 marks]

Answer: Ribosome, Mitochondrion, Chloroplast (1 mark)

The order can be inferred by which organisms have them: All cellular organisms have ribosomes, only Eukaryotes have Mitochondria, and only plants have chloroplasts.

(2 marks)

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e) Estimate the percentage of the volume of the cell that the nucleus takes up in Fig. (i), assuming that the cell can be approximated as a cube and the nucleus as a sphere.

(The volume of a sphere is $\frac{4}{3}\pi r^3$ where r is the radius of the sphere.)

[2 marks]

Answer: Students should show appropriate working, but do not actually need to convert values into the real measurements (1 mark)

.....

Answer can be between 6% and 20% (1 mark)

.....

.....

- f) Discuss how differences in the structure of the cells shown in Fig. (i) and (ii) affect the locations of different processes within these cells. [10 marks]

Answer:

Students should state that in eukaryotes:

Aerobic respiration occurs in Mitochondria (1 mark)

Photosynthesis occurs in Chloroplasts (1 mark)

DNA replication occurs in the Nucleus (1 mark)

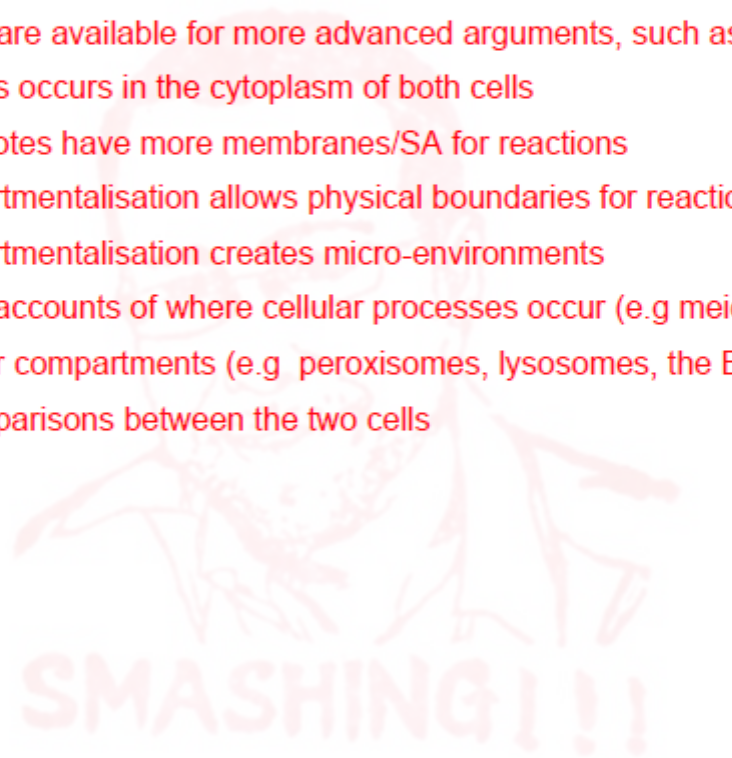
They should state that in bacteria:

Respiration and photosynthesis take place on the external membrane (1 mark)

DNA replication occurs in the cytoplasm (1 mark)

Further marks (up to 5) are available for more advanced arguments, such as:

- Knowing that glycolysis occurs in the cytoplasm of both cells
- Identifying that eukaryotes have more membranes/SA for reactions
- Identifying that compartmentalisation allows physical boundaries for reactions
- Identifying that compartmentalisation creates micro-environments
- Particularly advanced accounts of where cellular processes occur (e.g meiosis)
- Details of other cellular compartments (e.g peroxisomes, lysosomes, the ER, Golgi)
- Particularly direct comparisons between the two cells



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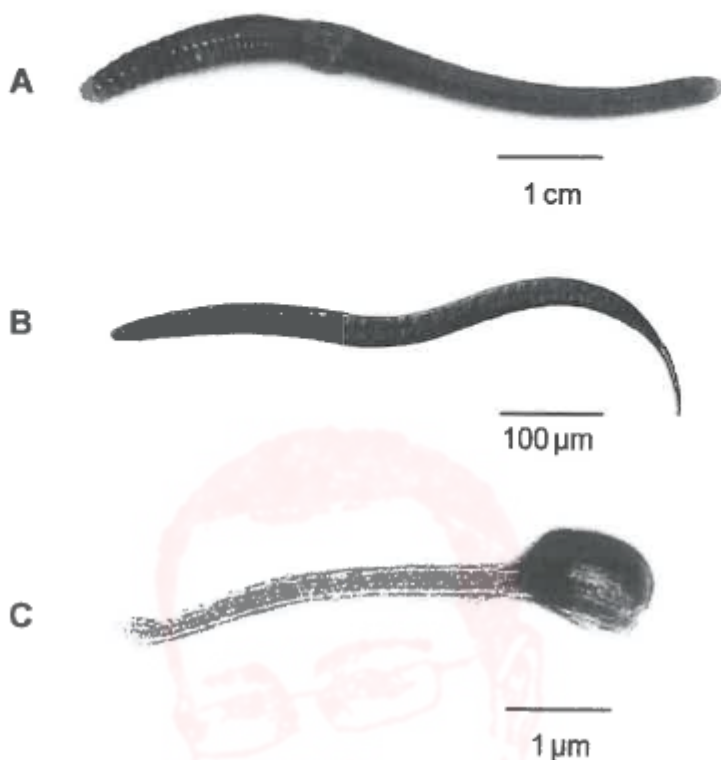
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.....

Question 6

Below are images of three species of organism, all of which are vermiform (worm-like) in appearance.



a) What is the approximate length of each species in mm?

[3 marks]

Answer:

A 1 mark: 60mm +/- 15mm

B 1 mark: 0.6mm +/- 0.15mm

C 1 mark: 0.005mm +/- 0.0015mm

b) What type of microscope has been used to produce the images of organisms B and C?

[2 marks]

Answer:

B 1 mark: Light microscope

C 1 mark: Electron microscope (TEM)

- c) For organism A, treating it as a tube, estimate the surface area:volume ratio, working in mm.
Show your working.

[4 marks]

Answer:

By treating the worm as a cylinder, the ratio comes out as approximately:

1.5 mm^{-1} OR approximately $2/R$

Values between 1 mm^{-1} and 2 mm^{-1} will be accepted, provided that working is correct (i.e do not punish if estimates are poor).

1 mark: correct equations (for tube or alternative)

1 mark: correct equation manipulation

1 mark: correct answer

1 mark: correct units

A summary of how they might do this is detailed below.

The student needs to use an approximation and treat the organism as an easily quantifiable object, ie a cylinder. However, the answer can vary depending on the level of approach used.

Finest level: the student will try to answer in a general mathematical way as below:

The worm is a cylinder, L = height of the cylinder and R = is the radius

The volume (V) will be $\rightarrow V = L \pi R^2$

The surface area (S) will be $\rightarrow S = L 2\pi R + 2\pi R^2$

Because in this organism/cylinder $L \gg R$ we can ignore $2\pi R^2$ and say that $S = L 2\pi R$

Then the ratio S over V is $\rightarrow S/V = L 2\pi R / L \pi R^2 = 2/R$

So the solution is $2/R$

Other approach: The student may approach the problem in the correct way – i.e. use the approximation of the worm being a cylinder – and calculate the S over V ratio using the formulae of V and S and coming up with a number. Of course, the numerical value will change depending on the estimate they give for L and R (according to the reference bar provided). When giving the numerical value it is important the student recognises that the ratio S over V has the dimension of cm^{-1} (or mm^{-1} , depending on the unit they use). So 1.5 of the answer is correct only if they express the values in mm.

d) How will the surface area:volume ratio differ between the three organisms?

[2 marks]

Answer:

2 marks: It will decrease as size gets bigger

.....
.....
.....
.....
.....
.....

e) Identify four substances that organism A may need to exchange with the external environment.

[2 marks]

Answer:

½ mark for each of:

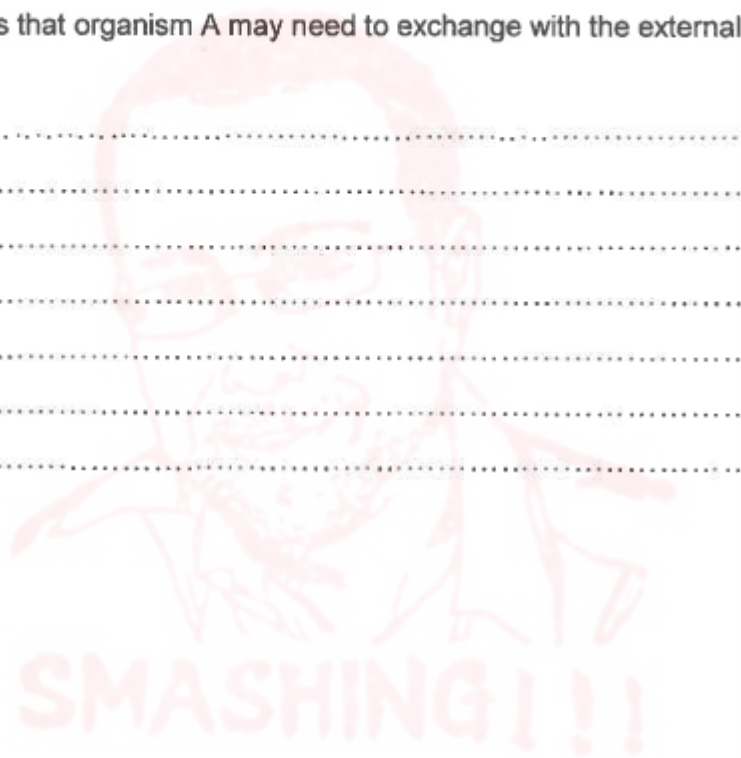
Oxygen

CO₂

Urea

Glucose

Viable alternatives



Party Z Biology

21 The answer is option **E**.

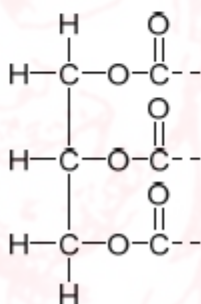
In the notation of a fatty acid, given in the question, the second value refers to the number of carbon–carbon double bonds. If a fatty acid has any of these bonds in the hydrocarbon chain it is unsaturated. The question shows that linoleic acid has two carbon–carbon double bonds and is therefore the most unsaturated fatty acid. Statement A is incorrect.

In the formation of a triglyceride, an atom of hydrogen is lost in the condensation reaction that forms the ester bond which attaches each fatty acid to the glycerol. This will leave 35 hydrogen atoms in the stearic acid component. Statement B is incorrect.

All fatty acids have a carboxyl group but in the formation of a triglyceride part of the group is lost in the condensation reaction that forms the ester bond. Statement C is incorrect.

The carbon–carbon double bonds in unsaturated fatty acids cause the chains to be kinked and not straight. As oleic and linoleic acids are both unsaturated, the hydrocarbon chains will not be in parallel. Statement D is incorrect.

In a triglyceride, there will be one oxygen atom in each ester bond plus 3 oxygen atoms attached by a double bond to the first carbon in each of the hydrocarbon chains as shown in the diagram:



This will give a total of 6 oxygen atoms in the triglyceride. The formula for a molecule of glucose is $C_6H_{12}O_6$. Statement E is correct.

Q# 226/ Section 2 Topic 2 Cambridge/2022/Section 2/ BIOLOGY NSAA/ www.SmashingScience.org

Q41	C
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Q# 227/ Section 2 Topic 3 Cambridge/2020/Section 2/ BIOLOGY NSAA/ www.SmashingScience.org

Q43	C
-----	---

Q# 228/ Section 2 Topic 3 Cambridge/2020/Section 2/ BIOLOGY NSAA/ www.SmashingScience.org

Q50	G
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- g) Discuss how temperature might affect net CO₂ uptake in plants, with reference to the effects of temperature on enzymatic activity. Use graphs to illustrate your answer.

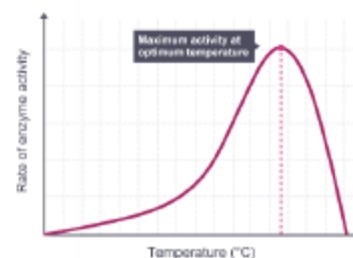
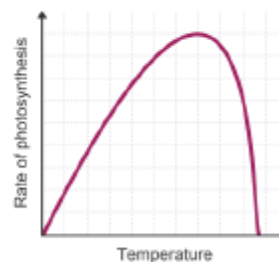
[10 marks]

Answer:

Students should discuss both photosynthesis and respiration, using reaction curves. There are basic points that should be made, but beyond this additional marks may be accrued for further insights

Basic points (1 mark each):

1. Depends upon relative rates of photosynthesis and respiration
2. Balance largely mediated through relative effects on enzyme activity
3. At low temperatures, rates are limited by molecular collisions between enzymes and substrates
4. At high temperatures, effects caused by denaturation of enzymes
5. Reaction curve for photosynthesis
6. Reaction curve for respiration (this may be generic)



Advanced points (1 mark each):

1. Mention of range of temperatures at which photosynthesis functions (0-50 degrees C) (or generic respiration)
2. Mention of optimum temperatures for photosynthesis (15-40 degrees C) (or generic respiration)
3. Comparisons of different types of plant
4. Mention of interactions with other limiting factors
5. Mention of anaerobic/aerobic effects
6. Mention of specific molecules involved in photosynthetic and respiratory reactions.
7. Attempt to super-impose and compare curves
8. Mention of temperature effects on diffusion of gases
9. Specific details on denaturation processes in enzyme
10. Anything else that is relevant.
11. 2 bonus points may be added for particularly in-depth descriptions of advanced conserations

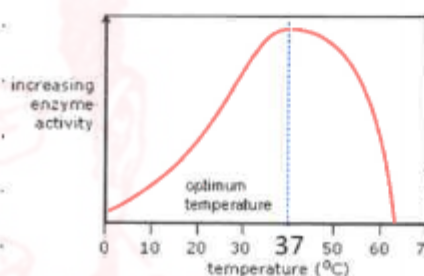
- g) *EcoRI* is produced by bacteria that often live harmlessly inside the human body. Explain how temperature and pH might affect the activity of *EcoRI* in bacterial cells, using diagrams if necessary. [12 marks]

Answer:

2 marks: Identifying that as temperature increases, the kinetic energy increases and enzymes will work at higher rate (provided that all the other limiting factors are in optimal supply) until the optimum temperature is reached (likely 37°C for enzymes adapted to the human body).

2 marks: Identifying If the temperature increases further, bonds that keep the enzyme (and substrate) structure in place will be altered and so binding will be altered and the rate of reaction will decrease. At high temperatures, denaturation may occur.

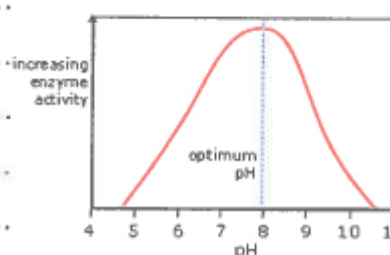
2 marks: Drawing a diagram of the changing rates of reaction (or explaining this in detail). Axes should be labelled.



2 marks: Identifying that pH affects enzymes' activity because changes in H^+ and OH^- affect the bonds within them. Such changes can affect the tertiary structure of the enzyme, denaturing it at extremes.

2 marks: identifying that alteration of the structure of the enzyme (and substrate) will affect binding of the substrate and thus the rate of reaction. The enzyme will have a pH optimum (*ECOR1* = 7.5). Below or above the optimum, the enzyme will work at a lower rate.

2 marks: Drawing of a diagram of the changing rates of reaction (or explaining this in detail). Axes should be labelled.



23 The answer is option F.

When the water potential of the cell sap and solution surrounding it are equal, the length of the plant tissue should remain the same. The initial length of plant tissue divided by the final length of plant tissue should be equal to 1. The cell sap and the salt solution have the same water potential at a salt solution concentration of 0.4 mol dm^{-3} .

At a salt solution concentration of 0.1 mol dm^{-3} the length of the plant tissue can be calculated:

$$5 \div 0.97 = \frac{5 \times 100}{97} = 5.15$$

Therefore the plant tissue increased by 0.15 cm which is equal to 1.5 mm.

Q# 232/ Section 2 Topic 4 Cambridge/2022/Section 2/ BIOLOGY NSAA/ www.SmashingScience.org

Q52	D
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Q# 233/ Section 2 Topic 4 Cambridge/2022/Section 2/ BIOLOGY NSAA/ www.SmashingScience.org

Q56	C
-----	---

Q# 234/ Section 2 Topic 4 Cambridge/2021/Section 2/ BIOLOGY NSAA/ www.SmashingScience.org

Q57	B
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Q# 235/ Section 2 Topic 4 Cambridge/2020sp/Section 2/ BIOLOGY NSAA/ www.SmashingScience.org

22 A

Q# 236/ Section 2 Topic 4 Cambridge/2020/Section 2/ BIOLOGY NSAA/ www.SmashingScience.org

Q46	G
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Q# 237/ Section 2 Topic 4 Cambridge/2020/Section 2/ BIOLOGY NSAA/ www.SmashingScience.org

Q58	D
-----	---

Q# 238/ Section 2 Topic 5 Cambridge/2022/Section 2/ BIOLOGY NSAA/ www.SmashingScience.org

Q51	D
-----	---

Q# 239/ Section 2 Topic 5 Cambridge/2020/Section 2/ BIOLOGY NSAA/ www.SmashingScience.org

Q54	F
-----	---

Q# 240/ Section 2 Topic 5 Cambridge/2020/Section 2/ BIOLOGY NSAA/ www.SmashingScience.org

Q55	A
-----	---

Q60

A

Q# 242/ Section 2 Topic 6 Cambridge/2018/Section 2/ BIOLOGY NSAA/ www.SmashingScience.org

- b) When RNA is translated into proteins, it is read in triplets (codons). What proportion of codons might be viewed as redundant in the genetic code (i.e. in excess of the minimum needed to make all amino acids)? (2 Marks)

A: 44/64 (one Mark for numerator and one Mark for denominator)

- c) What is an advantage of having more codons in the genetic code than there are amino acids? (2 Marks)

A: Point mutations may lead to same amino acid (1 Mark), which gives increased fault tolerance (1 Mark).

- d) A ribosome can translate 18 bases per second. How many seconds would it take to produce a protein that was 299 amino acids long? (2 Marks)

A: 897/18, or 49.833 (one Mark for 299x3, one Mark for calculation)

- e) Imagine that an alien organism is found that translates its RNA using pairs of nucleotides instead of triplets. During translation, the alien organism can produce 50 possible amino acids. What is the minimum number of different types of nucleotides that would be needed to produce all of the amino acids? (2 Marks)

A: 8 ($8^2 = 64$, 2 Marks for correct answer)

Q# 243/ Section 2 Topic 6 Cambridge/2016SP/Section 2/ BIOLOGY NSAA/ www.SmashingScience.org

No mark scheme available :o(

Q# 244/ Section 2 Topic 7 Cambridge/2022sp/Section 2/ BIOLOGY NSAA/ www.SmashingScience.org

26 The answer is option B.

A mature sieve tube element is made up of many adjacent cells fusing together with holes appearing in adjacent cell walls. These cell walls contain the structural polysaccharide cellulose. The mature element also has cytoplasm which contains mitochondria.

One way to work out the diameter of the cross-sectional area is:

$$\frac{54\pi}{6} = 9\pi$$

$$9\pi = \pi r^2$$

$$\frac{9\pi}{\pi} = r^2$$

$$r^2 = 9$$

$$r = \sqrt{9} = 3$$

$$d = 2r = 6$$



27 The answer is option **F**.

In order to calculate the volume of water lost, we use the volume of the tubing, which is a cylinder:

$$\text{volume of cylinder} = \pi r^2 h$$

For P, this is $\pi \times 0.3^2 \times 90 = \pi \times 0.09 \times 90 = 8.10\pi$

For Q, this is $\pi \times 0.5^2 \times 33 = \pi \times 0.25 \times 33 = 8.25\pi$

For R, this is $\pi \times 0.6^2 \times 25 = \pi \times 0.36 \times 25 = 9.00\pi$

Therefore, the order from most to least is: R, Q, P.

The information provided does not specify anything about controlling variables, so it is possible that R was in a humid environment. However, the loss of water (transpiration) under these conditions is expected to be very low, not the most water lost.

There is also no indication that the leaf area was the same in all three experiments, nor that other variables were controlled.

Therefore, it is only possible to say there is insufficient data to explain the results.

Q# 246/ Section 2 Topic 7 Cambridge/2022/Section 2/ BIOLOGY NSAA/ www.SmashingScience.org

Q53	E
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Q# 247/ Section 2 Topic 7 Cambridge/2021/Section 2/ BIOLOGY NSAA/ www.SmashingScience.org

Q50	B
-----	---

Q# 248/ Section 2 Topic 7 Cambridge/2020sp/Section 2/ BIOLOGY NSAA/ www.SmashingScience.org

27 F

Q# 249/ Section 2 Topic 7 Cambridge/2020/Section 2/ BIOLOGY NSAA/ www.SmashingScience.org

Q51	A
-----	---

22 The answer is option C.

Cardiac output is calculated by the equation:

$$\text{cardiac output} = \text{heart rate} \times \text{stroke volume}$$

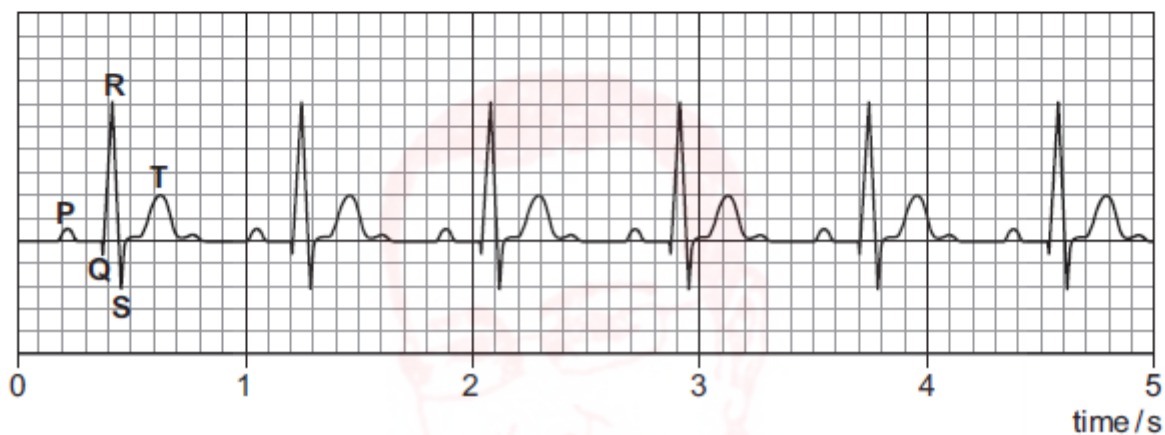
The stroke volume is given in the stem of the question, 70 cm^3 . There are 6 beats in 5 seconds shown on the ECG which needs to be multiplied by 12 to give the heart rate per minute.

Cardiac output is:

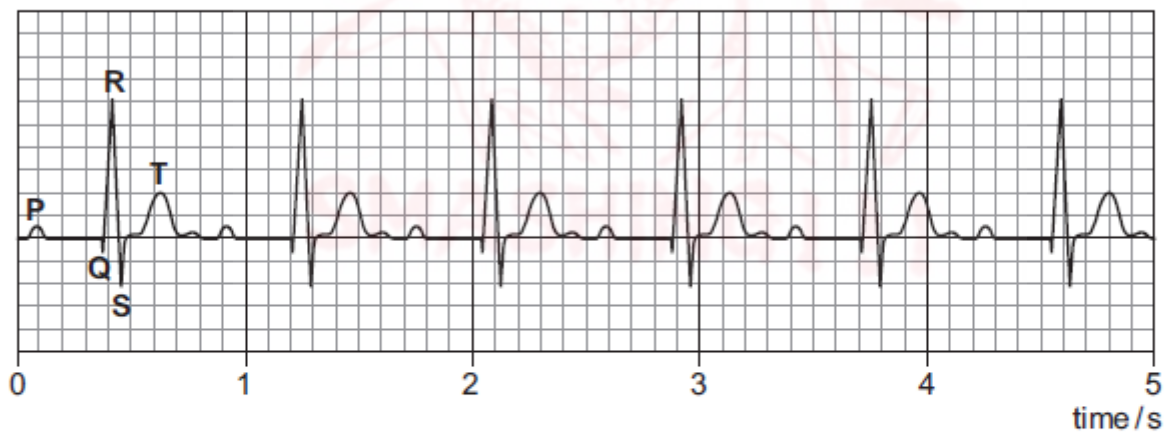
$$72 \times 70 = 5040 \text{ cm}^3 \text{ per minute}$$

Therefore, statement 1 is not correct.

A normal ECG:



Abnormal ECG from person with known cardiac condition:



In the normal ECG the P wave is next to the QRS complex. In the abnormal ECG there is a short gap between the P wave and the QRS complex. The P wave represents atrial systole as the electrical activity spreads over the atria. The QRS complex represents ventricular systole as the electrical activity spreads over the ventricles. In the normal cardiac cycle ventricular systole follows immediately after atrial systole, as seen in the normal ECG. In the abnormal ECG the gap between P and QRS indicates that electrical conduction does not follow as quickly as it should. Statement 2 is correct.

P represents atrial systole, not atrial diastole. Statement 3 is not correct.

Q42	G
-----	---

Q47	G
-----	---

Q48	D
-----	---

Q49	F
-----	---

Q42	C
-----	---

- f) Discuss how the size of organisms affects their ease of exchange of substances with the external environment. You should highlight at least two adaptations that help overcome the constraints of size.

[12 mar

Answer:

2 marks: Identifying that adaptations to increase surface areas for exchange are often necessary in large animals.

2 marks: Identifying that in some small animals, exchange of substances over their surface may be an issue (e.g with dehydration)

4 marks: Detailed explanation of one adaptation that may help facilitate or prevent exchange. Adaptations may include root hairs, gills, lungs, etc. One mark should be deducted if students do not highlight at least two characteristics of each adaptation (e.g. S.A, short diffusion distance, counter-current exchange etc). One mark should be deducted if no numerical values are given.

4 marks: Detailed explanation of a second adaptation that may help facilitate or prevent exchange. Adaptations may include root hairs, gills, lungs, etc. One mark should be deducted if students do not highlight at least two characteristics of each adaptation (e.g. S.A, short diffusion distance, counter-current exchange etc). One mark should be deducted if no numerical values are given.

Up to 2 marks may be deducted for particularly incoherent arguments.

Note that for this section, sample scripts will be circulated by Friday 11th November for comparison.

Q# 257/ Section 2 Topic 9 Cambridge/2022/Section 2/ BIOLOGY NSAA/ www.SmashingScience.org

Q45	G
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Q# 258/ Section 2 Topic 9 Cambridge/2020/Section 2/ BIOLOGY NSAA/ www.SmashingScience.org

Q49	B
-----	---

Q# 259/ Section 2 Topic 10 Cambridge/2022/Section 2/ BIOLOGY NSAA/ www.SmashingScience.org

Q50	G
-----	---

Q# 260/ Section 2 Topic 10 Cambridge/2020sp/Section 2/ BIOLOGY NSAA/ www.SmashingScience.org

24 E

Q# 261/ Section 2 Topic 11 Cambridge/2022/Section 2/ BIOLOGY NSAA/ www.SmashingScience.org

Q46	E
-----	---

Q# 262/ Section 2 Topic 11 Cambridge/2020sp/Section 2/ BIOLOGY NSAA/ www.SmashingScience.org

21 E

Q# 263/ Section 2 Topic 12 Cambridge/2021/Section 2/ BIOLOGY NSAA/ www.SmashingScience.org

Q46	B
-----	---

Q# 264/ Section 2 Topic 12 Cambridge/2021/Section 2/ BIOLOGY NSAA/ www.SmashingScience.org

Q56	F
-----	---

Q# 265/ Section 2 Topic 12 Cambridge/2020/Section 2/ BIOLOGY NSAA/ www.SmashingScience.org

Q52	D
-----	---

29 The answer is option C.

The gaseous product of photosynthesis is oxygen. Statement 1 is not correct.

Any of the points where the distance doubles can be used to test Statement 2. Several intervals should be checked to confirm the relationship.

Between 10 cm and 50 cm, the relationship between the rate of gas production (photosynthesis) and distance from the light source matches the inverse square relationship between distance from the light source and light intensity, e.g. as the distance doubles (from 10 cm to 20 cm) the light intensity will decrease to:

$$\left(\frac{1}{d^2}\right) = \left(\frac{1}{2^2}\right) = \frac{1}{4} \text{ of the original value}$$

This matches the decrease in photosynthesis, which decreases by a factor of 4, from 80 to 20 bubbles.

Similarly, as the distance goes up from 10 cm to 40 cm the light intensity will decrease to $\left(\frac{1}{4^2}\right) = \frac{1}{16}$ of the original value, again matching the decrease in photosynthesis, from 80 to 5 bubbles.

Therefore, statement 2 is correct.

As the pondweed is moved closer than 10 cm to the light source, light intensity will be increasing but the rate of photosynthesis does not increase. Therefore, some factor other than light intensity must be rate limiting at 5 cm. Statement 3 is not correct.

Q44	D
-----	---

Q42	D
-----	---

Q44	C
-----	---

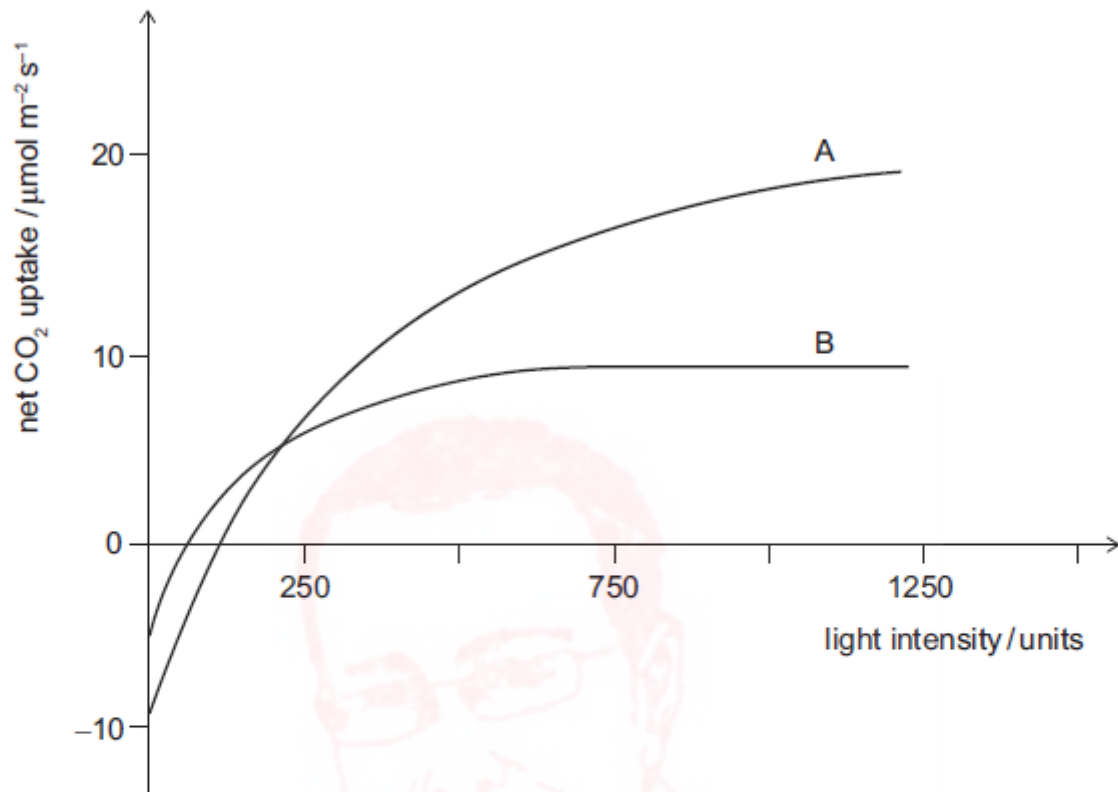
25 H

29 C



Question B2

The graph shows net CO₂ uptake of two different plants, A and B, when exposed to increasing light levels.



a) Name two physiological processes that affect the net CO₂ uptake in plants.

[1 mark]

Answer: **Photosynthesis + respiration**

b) State what can be concluded when the net CO₂ uptake in each plant is zero.

[1 mark]

Answer: **The rate of photosynthesis is equal to the rate of respiration**

- c) For plant B, estimate the value at which increasing light intensity no longer affects CO₂ uptake. [1 mark]

Answer: **650-700** (some 1/2 marks were given if the student was close)

- d) Estimate the number of micromoles of CO₂ that would be taken up by a 50 cm² leaf of plant B in one minute at light intensity of 750 units.

[2 marks]

Answer: **$9 \times 0.005\text{m}^2 \times 60 = 2.7\mu\text{mol}$ (2.4 -2.9 accepted)**
(1 mark lost for each unit not adjusted)

- e) Propose two explanations for the existence of a plateau in the curve for plant B.

[2 marks]

Answer: **Factors other than incident light limit photosynthesis (1 mark).**

These may include temperature, CO₂ levels, or enzymatic activity of the enzymes involved in the process (1 mark each, including if 1st mark not awarded).

- f) Describe the differences in the curves for plants A and B and suggest why these differences might occur.

[3 marks]

Answer: **Plant B has a higher CO₂ uptake in low light intensities (1 mark)**

Plant B reaches a lower plateau (light saturation point) (1 mark)

It would be found in plants that are adapted to living in low light conditions (1 mark)

Q# 273/ Section 2 Topic 14 Cambridge/2022/Section 2/ BIOLOGY NSAA/ www.SmashingScience.org

Q54

G

Q55	E
-----	---

Q51	D
-----	---

Q55	E
-----	---

Q47	D
-----	---

Q57	F
-----	---

25 The answer is option A.

Cell X is a haploid cell with 7 chromosomes in prophase II of meiosis. This means the cell has already been through prophase I, metaphase I, anaphase I and telophase I since the end of interphase. Statement 1 is not correct.

All of the cells contain a similar total mass of DNA. Cell X and Cell Z both have a chromosome number of 7, which means that meiosis I has happened. In these cells, each chromosome has two chromatids so there is a total of 14 chromatids in each cell. Cell Y has 14 chromosomes, but these have not duplicated yet so there are also 14 chromatids present in this cell. Statement 2 is not correct.

There are only 7 chromosomes in Cell Z, therefore it is a haploid cell and not in mitosis. Statement 3 is not correct.

28 The answer is option G.

The process of increasing the variation between the two groups of maize grains is not a natural one, but carried out in an experiment artificially. Statement 1 is not correct.

The graph shows that the percentage oil content in the high oil content grains was 5% at the start of the experiment. This increased to 14% after 50 generations.

Percentage change is:

$$\begin{aligned} & \frac{\text{change in percentage oil content}}{\text{oil content at start}} \times 100\% \\ &= \frac{(14 - 5)}{5} \times 100\% \\ &= 180\% \end{aligned}$$

Statement 2 is correct.

The maize grains had a mean mass of 0.4 g. At the start of the experiment for the high oil content grains, 5% of this mass was oil:

$$\frac{5}{100} \times 0.4 = 0.02 \text{ g}$$

After fifty generations, 14% of each grain was oil:

$$\frac{14}{100} \times 0.4 = 0.056 \text{ g}$$

The difference is $0.056 - 0.02 = 0.036 \text{ g}$

Statement 3 is correct.

Q58	D
-----	---

Q59	B
-----	---

Q41	E
-----	---

Q53	G
-----	---



Q# 285/ Section 2 Topic 16 Cambridge/2021/Section 2/ BIOLOGY NSAA/ www.SmashingScience.org

Q54	H
-----	---

Q# 286/ Section 2 Topic 16 Cambridge/2021/Section 2/ BIOLOGY NSAA/ www.SmashingScience.org

Q59	C
-----	---

Q# 287/ Section 2 Topic 16 Cambridge/2020sp/Section 2/ BIOLOGY NSAA/ www.SmashingScience.org

26 H

Q# 288/ Section 2 Topic 16 Cambridge/2020sp/Section 2/ BIOLOGY NSAA/ www.SmashingScience.org

28 G

Q# 289/ Section 2 Topic 16 Cambridge/2020sp/Section 2/ BIOLOGY NSAA/ www.SmashingScience.org

30 E

Q# 290/ Section 2 Topic 16 Cambridge/2020/Section 2/ BIOLOGY NSAA/ www.SmashingScience.org

Q41	B
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Q# 291/ Section 2 Topic 16 Cambridge/2020/Section 2/ BIOLOGY NSAA/ www.SmashingScience.org

Q44	H
-----	---

Q# 292/ Section 2 Topic 16 Cambridge/2020/Section 2/ BIOLOGY NSAA/ www.SmashingScience.org

Q45	C
-----	---

Q# 293/ Section 2 Topic 16 Cambridge/2020/Section 2/ BIOLOGY NSAA/ www.SmashingScience.org

Q48	B
-----	---

Q# 294/ Section 2 Topic 16 Cambridge/2020/Section 2/ BIOLOGY NSAA/ www.SmashingScience.org

Q57	E
-----	---

Q# 295/ Section 2 Topic 16 Cambridge/2020/Section 2/ BIOLOGY NSAA/ www.SmashingScience.org

Q59	D
-----	---

Q# 296/ Section 2 Topic 16 Cambridge/2018/Section 2/ BIOLOGY NSAA/ www.SmashingScience.org

- f) Using examples, describe the changes that can occur in DNA sequences and how these can lead to genetic diseases. (10 Marks)

A: 2 Marks each for explaining the importance of the following, with mention of the effects that they can have:

Substitution (change in aas, premature chain termination)

Deletion (loss of aas, genes + frameshifts)

Insertion (gain in aas, frameshifts)

2 Marks for each of two specific examples of diseases (with some detail)

Question B2

- a) From the following list of organisms identify one that can reproduce itself **(i)** without using mitosis or meiosis, and **(ii)** using *either* mitosis alone or meiosis.

- 1 *Homo sapiens*
- 2 *Fragaria ananassa* (strawberry)
- 3 *Escherichia coli*

[2 marks]

Answer:

- (i) *E. coli* (1 mark)
 (ii) *F. ananassa* (1 mark)

- b) For the processes of mitosis and meiosis, draw separate line graphs to show how the relative amount of DNA in a single healthy dividing cell changes with time.

You should label the axes on the graphs.

(Assume that no mutations occur.)

[3 marks]

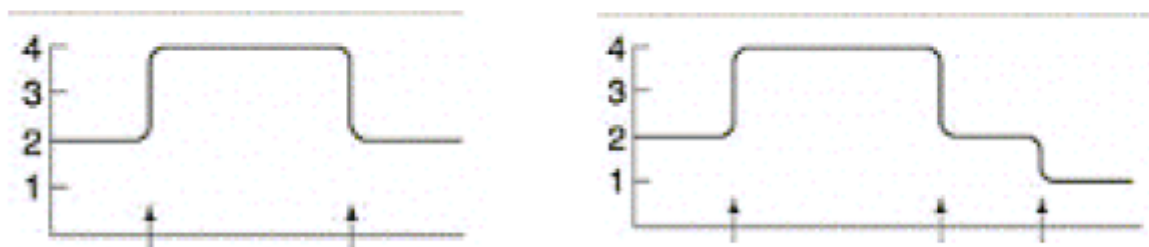
Answer:

Figures can vary slightly, but should have:

Axes with time and relative amount of DNA (1 mark)

A clear doubling and halving of the amount of DNA in Mitosis (1 mark)

A clear second round of halving in Meiosis (1 mark)



- c) Calculate how many possible combinations of chromosomes could be produced in each gamete during sexual reproduction in humans (assuming no recombination). **[2 marks]**

Answer: $2^{23} = 8388608$ (either will do)

.....

.....

.....

- d) A female has a recessive disease-causing allele on one of her non-sex-determining chromosomes. She mates with a male with the same disease-causing allele on one of his chromosomes. They have one child. Assuming that no mutations occur, what is the probability that:

- (i) this child will have the disease? **[1 mark]**

Answer: $1/4$ (1 mark)

.....

.....

- (ii) this child is male and does not have the disease? **[2 marks]**

Answer: $3/8$ (2 marks)

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Q# 298/ Section 2 Topic 16 Cambridge/2016SP/Section 2/ BIOLOGY NSAA/ www.SmashingScience.org
No mark scheme available :o(

30 The answer is option **E**.

Statement 1 is correct.

$\frac{3}{4}$ of the alleles are the dominant B allele, so the probabilities of each genotype are

	B $\frac{3}{4}$	b $\frac{1}{4}$
B $\frac{3}{4}$	$\frac{9}{16}$	$\frac{3}{16}$
b $\frac{1}{4}$	$\frac{3}{16}$	$\frac{1}{16}$

Flour beetles with genotypes BB and Bb will have black eyes.

The proportion of black eye beetles will be: $\frac{9}{16} + \frac{3}{16} + \frac{3}{16} = \frac{15}{16}$

Therefore the number of beetles with black eyes in the population is: $\frac{15}{16} \times 1600 = 1500$

Statement 2 is correct. The body cells each have two copies of chromosome 5, and this means they are diploid.

Statement 3 is not correct.

For this population of beetles, using the probabilities in the table for Statement 1:

homozygous black eye (BB) = $\frac{9}{16}$

heterozygous black eye (Bb) = $\frac{3}{16} + \frac{3}{16}$

red eye (bb) = $\frac{1}{16}$

Therefore the ratio of homozygous black eye beetles to heterozygous black eye beetles to red eye beetles is 9:6:1

Q60	B
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e) Discuss:

- (i) how different mechanisms of reproduction affect the levels of variation in the next generation;
- (ii) how variation affects the likelihood of survival in a changing environment.

[10 marks]

Answer:

Students should:

1. State that Asexual organisms produce clones with little variation (1 mark)
2. State that Sexual organisms have increased variation in offspring (1 mark)
3. Explain one way in which variation is generated by sex (e.g independent assortment, recombination, random fertilisation etc) (1 mark)
4. State a factor that influences variation in both reproductive types (environment, mutation) (1 mark)
5. State that variation leads to differential survival and those best adapted survive (1 mark)

Further marks (up to 5) are available for more advanced arguments, such as:

- Outlining more than one way in which variation is generated in sexual organisms
- Explaining how variation can be generated in an asexual organism (e.g environment, conjugation)
- Giving specific examples of either type of reproduction.
- Referring to the genetics of variation (e.g. mendelian genetics, polygenic systems)
- Explaining that sexual organisms may be more prone to extinction because they cannot adapt quickly enough.
- Giving a particularly detailed account of natural selection
- Giving a specific example of where selection acts upon variation

24 The answer is option **E**.

Using data from the bar chart, there are 42 mammals in the owl's diet of which 6 are mice:

$$\frac{6}{42} \times 100 = 14.3\%$$

The change in the population (r) can be calculated by adding together the births (b) and immigration (i), adding together the deaths (d) and emigration (e), then subtracting the second figure from the first, as in the equation:

$$r = (b + i) - (d + e)$$

$$(242 + 11) - (207 + 21) = 25$$

However, this figure is for 2 weeks. The mean change per week is $25 \div 2 = 12.5$

Although this figure shows there is an increase in the mouse population, it is not possible to make a judgement on whether the owl's diet would be likely or unlikely to show an increase in mice, because there is no data available about what is happening to the populations of the other organisms in the owl's diet. The only sound conclusion is that there is insufficient evidence to know the effect on the owl's diet.

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Q43	E
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Q# 306/ Section 2 Topic 18 Cambridge/2021/Section 2/ BIOLOGY NSAA/ www.SmashingScience.org

Q45	E
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Q# 307/ Section 2 Topic 18 Cambridge/2021/Section 2/ BIOLOGY NSAA/ www.SmashingScience.org

Q58	G
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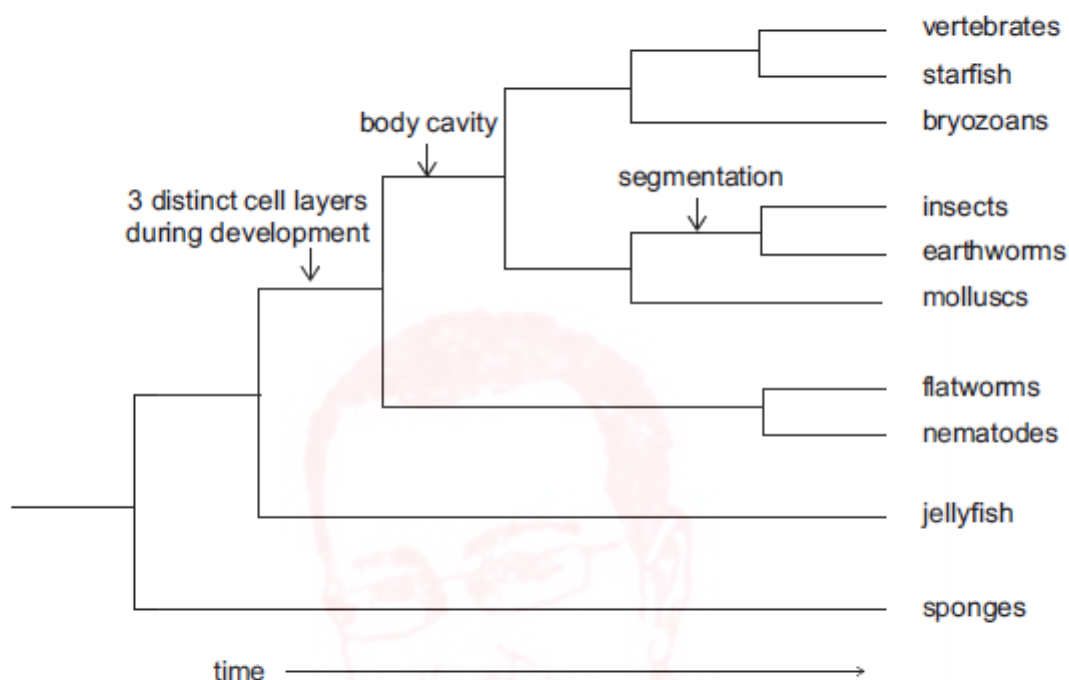
Q# 308/ Section 2 Topic 18 Cambridge/2020sp/Section 2/ BIOLOGY NSAA/ www.SmashingScience.org

23 E



Question B1

The diagram shows an evolutionary tree for a kingdom of organisms. This tree was constructed over 20 years ago using shared observable features to group these organisms into smaller groups. The time at which three of these shared features first appeared is shown on the evolutionary tree. Each branching point in the tree indicates the time at which groups of organisms diverged from a common ancestor.



- a) Identify the kingdom represented in this evolutionary tree.

[1 mark]

Answer: **ANIMALIA**

- b) Recently, molecular evidence has changed our understanding of these relationships. Based upon each of the three findings below, what conclusions about evolution can you draw?

- (i) Insects and earthworms are not closely related to each other.

[1 mark]

Answer:

Segmentation is not a good indicator of relatedness/ it must have evolved independently (or ancestrally)

(ii) Nematodes and insects, both of which undergo moulting, are very closely related.

[2 marks]

Answer:

Moulting arose in their common ancestor and is a good indicator of relatedness (1 Mark).

The above tree is incorrect (1 mark).

.....
.....
.....

(iii) Flatworms, which all lack a true body cavity, are not actually a single group. Some diverged at the base of the tree, some are related to the molluscs, and some are related to starfish and vertebrates.

[2 marks]

Answer:

Absence of body cavity is not a good indicator of relatedness (1 mark).

It must have been lost independently, or the body cavity arose on many separate occasions (1 mark).

c) Briefly describe two benefits of using molecular evidence to construct trees, rather than visible characteristics.

[2 marks]

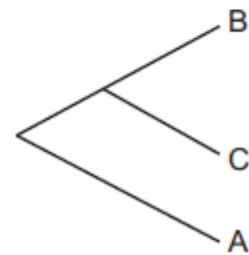
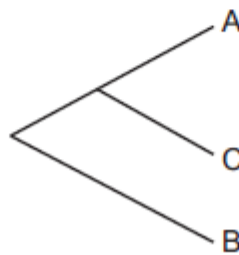
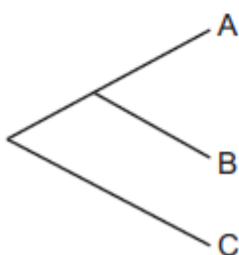
Answer:

Genetics provides a huge amount of data that can be used to construct trees (1 mark).

There is less convergence at the molecular level (1 mark)

.....
.....
.....

d) The following three tree diagrams show **all** of the possible relationships between 3 different organisms.



Answer:

There are 15 trees, 12 with branching patterns of:

....and a further 3 with a different branching pattern:.



1 Mark should be awarded for an answer of 12, and 2 Marks for an answer of 15.

e) Using examples, discuss the different ways by which we can measure biodiversity.

[10 marks]

Answer:

There are basic points that should be made, but beyond this additional marks may be accrued for further insights

Basic points:

1. Definition: the variety and complexity of life
2. Can be measured at a Genetic level
3. Can be measured at a Population level
4. Can be measured at a Habitat level (i.e. no species)

Advanced points:

1. Description of genetic variation
2. Mention of the importance of mutation in causing genetic differences
3. Discussion of the quantification of genetic differences (within + between species)
4. Discussion of classificatory systems
5. Discussion of the concept of a species
6. Mention that new new classificatory systems move beyond observable features
7. Mention of the role of Natural selection in causing diversity
8. Discussion of behavioural, physiological and anatomical adaptations

8. Discussion of behavioural, physiological and anatomical adaptations

9. Mention of how quadrats and belt transects are used to investigate the distribution and abundance of organisms in a habitat.

10. Explanation of how to determine the number of organisms in a given area.

11. 2 bonus points may be added for particularly in-depth descriptions of advanced conserations

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f) Discuss the factors that may affect the spread and photosynthetic rate of the plant. (10 Marks)

A. 2 Marks for discussing each of the following (up to a maximum of 10):

Limits to transmission (e.g. vectors for pollen, seeds)

Limitations on spread from competition (inter-specific)

Limitations on spread due to reproduction/growth rate

Limitations on spread do to environmental conditions

Effects of light intensity on photosynthesis

Effects of CO₂ levels on photosynthesis

Effects of temperature on photosynthesis

+ Any other sensible idea not related to the above

To get the full 2 Marks for each topic, students should have a level of specificity in their answers and not just state that a factor "has an effect". For the photosynthetic element, graphs or detailed descriptions are expected.

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B2

a) Describe one benefit and one problem associated with using quadrats in a study like this. (2 Marks)

A: Benefit: increased speed/lower effort (1 Mark)

Problem: Sample error (1 Mark)

b) Calculate the frequency of occurrence of the species in the quadrats. (1 Mark)

A. 6/8 (1 Mark)

c) Calculate the mean number of plants found per square metre in the quadrats (1 Mark)

A. 12/32 (1 Mark for mean per quadrat, 1 Mark for mean per metre)

d) For the field as a whole, the population grows by 70 individuals per week. How long will the population take to reach an average density of two plants per square metre in the whole field? (2 Marks)

A. 25 days (1 Mark for calculating final number of plants, 1 Mark for calculating time)

e) This invasive plant only produces flowers every 5 years. Why might this occur? (3 Marks)

- A. One Mark each for identifying:**
Importance of synchrony with pollinators
Importance of asexual reproduction
Importance of resource build-up
(or 1 Mark for other sensible ideas)

f) Discuss the factors that may affect the spread and photosynthetic rate of the plant. (10 Marks)

- A. 2 Marks for discussing each of the following (up to a maximum of 10):**
Limits to transmission (e.g. vectors for pollen, seeds)
Limitations on spread from competition (inter-specific)
Limitations on spread due to reproduction/growth rate
Limitations on spread due to environmental conditions
Effects of light intensity on photosynthesis
Effects of CO₂ levels on photosynthesis
Effects of temperature on photosynthesis
+ Any other sensible idea not related to the above

To get the full 2 Marks for each topic, students should have a level of specificity in their answers and not just state that a factor "has an effect". For the photosynthetic element, graphs or detailed descriptions are expected.

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No mark scheme available :o(

Q# 313/ Section 2 Topic 18 Cambridge/2016SP/Section 2/ BIOLOGY NSAA/ www.SmashingScience.org

No mark scheme available :o(

Q# 314/ Section 2 Topic 18 Cambridge/2016SP/Section 2/ BIOLOGY NSAA/ www.SmashingScience.org

No mark scheme available :o(

Q# 315/ Section 2 Topic 19 Cambridge/2022/Section 2/ BIOLOGY NSAA/ www.SmashingScience.org

Q43	A
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Q# 316/ Section 2 Topic 19 Cambridge/2022/Section 2/ BIOLOGY NSAA/ www.SmashingScience.org

Q49	G
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Q# 317/ Section 2 Topic 19 Cambridge/2022/Section 2/ BIOLOGY NSAA/ www.SmashingScience.org

Q60	H
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Q# 318/ Section 2 Topic 19 Cambridge/2020/Section 2/ BIOLOGY NSAA/ www.SmashingScience.org

Q56	D
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Biology

Question 5

EcoRI is a restriction enzyme that cuts bacterial DNA into pieces at specific sequences.

a) What type of biological molecule is *EcoRI*?

[1 mark]

Answer: **1 mark: a Protein**

b) Name the type of bond between adjacent nucleotides that is cut by *EcoRI*.

[1 mark]

Answer: **1 mark: Phosphodiester bond 1/2 mark: Covalent bond**

c) *EcoRI* cuts at specific sites in the DNA, characterised by the sequence GAATTC. Other restriction enzymes cut at specific sequences like GGATCC or AGCT. What characteristic do these sequences have in common and how might this characteristic aid in cutting?

[3 marks]

Answer:

2 marks: Identifying that these sequences are palindromic, and so reading 5' to 3' forward on one strand matches the sequence reading backward 5' to 3' on the complementary strand.

1 mark: Identifying that this type of sequence allows the same enzyme to make cuts on both strands at the same site.

d) *EcoRI* is produced by bacteria. What role might it have in a bacterial cell?

[1 mark]

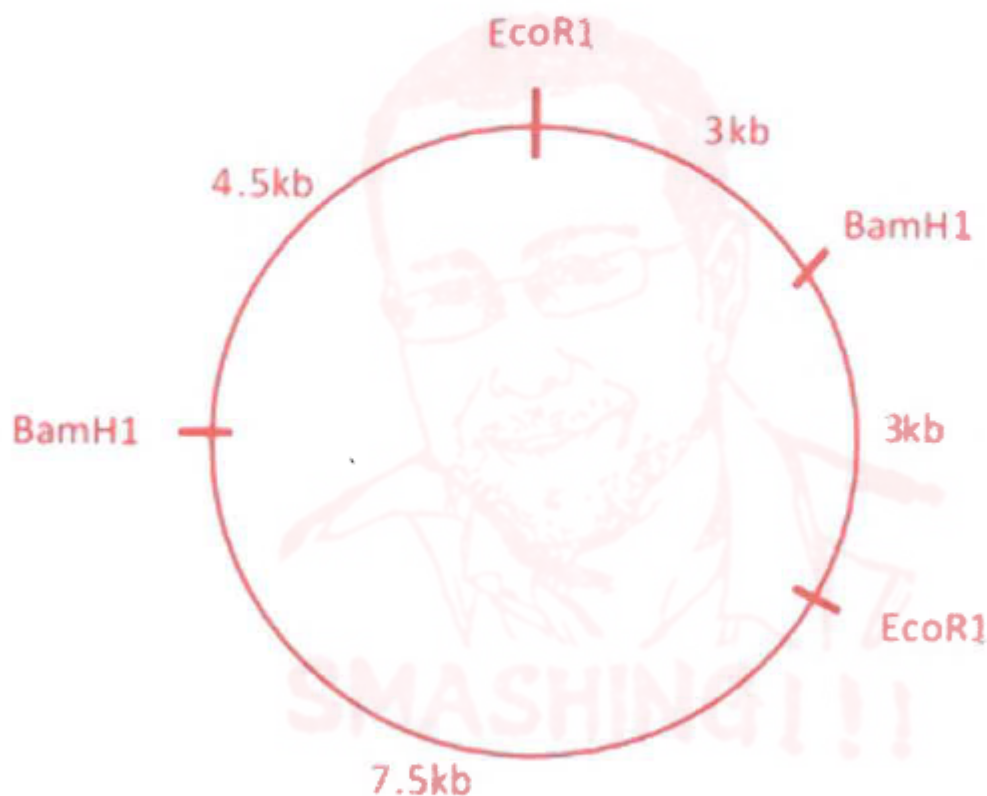
Answer: **1 mark: To cut viral DNA (as a defence mechanism).**

- e) We can use different restriction enzymes to cut DNA at different sites. Another restriction enzyme is *Bam*HI. By studying the fragments produced by different combinations of restriction enzymes we can produce a map of the cutting sites of these enzymes.

Use the data in the table below to produce a map of the cutting sites of restriction enzymes. This map should be drawn onto a circle of bacterial plasmid DNA, the total length of which is 18 kb. Distances between the cut sites should be identified. **[4 marks]**

enzyme used	fragment sizes produced / kb
<i>Eco</i> RI alone	6, 12
<i>Bam</i> HI alone	7.5, 10.5
<i>Eco</i> RI and <i>Bam</i> HI together	3, 3, 4.5, 7.5

Answer:



1 mark for drawing a circle with cuts

1 mark for identifying correct number of cuts

1 mark for correct labelling

1 mark for correct diagram (although the one above could be mirrored)

f) Suggest how enzymes like *EcoRI* could be used in genetic engineering.

[3 marks]

Answer:

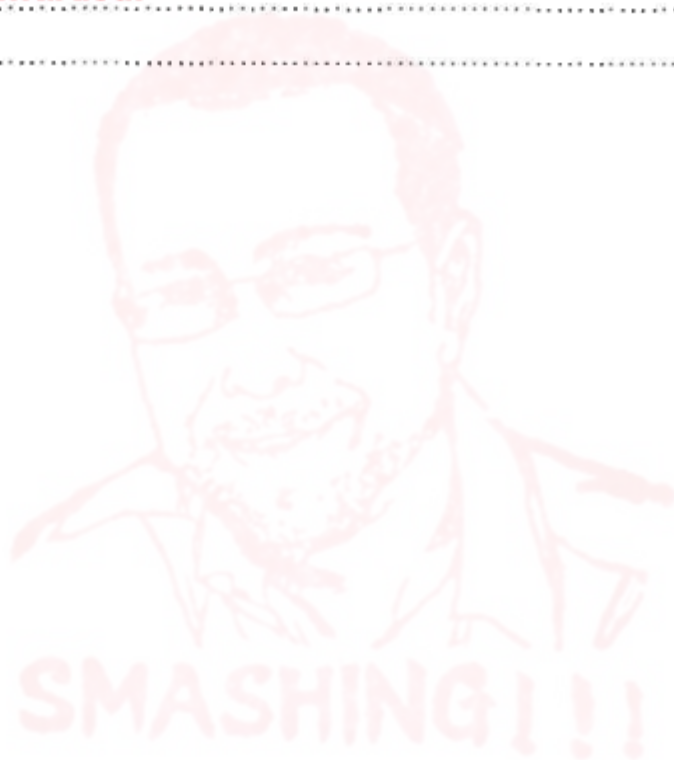
1 mark: Identifying that genes from humans and other organisms can be 'cut out' using enzymes and transferred to cells of other organisms.

1 mark: Identifying that if transferred into a bacterium, the bacterium will produce the protein product.

1 mark: Specific example.

1 mark: Discussion of the modification of a genome to cure disease.

Maximum 3 marks awarded.



Appendix: ESAT syllabus mapped to CAIE A Level Biology

The ESAT biology syllabus delivers a really broad approach to the CAIE 9700 syllabus.

One way to better understand exactly what could be assessed would be to focus on the subtopics rather than the topics themselves. A less exhaustive and exhausting way, but rough way to get an idea of what could be in the syllabus would be to go through each question and tick with a pen which subtopic in the A Level syllabus appears. The subtopics with the most ticks are the most important. When you have gone through every question you will have a good idea on which subtopics to put special care, with both AS level MCQ Paper 1 questions and IB Higher Level Biology Paper 1 questions, into those subtopics.

A very well-prepared student, however, would have already finished the A2 syllabus before the interview in November/December of their A2 year. One strategy is to sit the A2 exam in November for the subject you are applying to study at university to help drive and direct your learning.

ESAT Topic	CAIE Topic	NSAA Topic Details
B1. Cells	T1 Cell structure	<p>B1.1 Know and understand the structure and function of the main sub-cellular components of eukaryotic cells (both animal and plant) including:</p> <ul style="list-style-type: none"> a. cell membrane b. cytoplasm c. nucleus d. mitochondrion e. cell wall (plant only) f. chloroplast (plant only) g. vacuole (plant only) <p>B1.2 Know and understand the structure and function of the main sub-cellular components of prokaryotic cells (bacteria) including:</p> <ul style="list-style-type: none"> a. cell membrane b. cytoplasm c. cell wall d. chromosomal DNA/no 'true' nucleus e. plasmid DNA <p>B1.3 Know and understand the levels of organisation within organisms as: cells to tissues to organs to organ systems.</p>
B2. Movement across membranes	T4 Cell membranes and transport	<p>B2.1 Know and understand the processes of diffusion, osmosis (in terms of water potential), and active transport, including examples in living and non-living systems.</p>
B3. Cell division and sex determination	T5 The mitotic cell cycle; T16 Inheritance	<p>B3.1 Mitosis and the cell cycle:</p> <ul style="list-style-type: none"> a. Know and understand that the mitotic cell cycle includes interphase (involving cell growth and DNA replication) and mitosis (involving one cell division leading to two daughter cells which are genetically identical to each other and to the parental cell). b. Know and understand the importance of mitosis in the growth of an organism: specifically, its roles in increasing the number of cells, repairing tissues, replacing cells and asexual reproduction. c. Know and understand that cancer is the result of changes in cells, including mutations, that

ESAT Topic	CAIE Topic	NSAA Topic Details
		<p>lead to uncontrolled cell division.</p> <p>B3.2 Meiosis and the cell cycle:</p> <ol style="list-style-type: none"> Know and understand that the meiotic cell cycle includes interphase (involving cell growth and DNA replication) and meiosis (involving two cell divisions leading to four daughter cells, each with a single copy of each chromosome). Know and understand the role of meiosis in producing genetically different haploid gametes so that the zygote (fertilised egg cell) produced at fertilisation is diploid. <p>B3.3 Asexual and sexual reproduction:</p> <ol style="list-style-type: none"> Know and understand that asexual reproduction involves one parent and that offspring are genetically identical when no mutations occur. Know and understand that sexual reproduction involves two parents and that offspring are genetically different in relation to each other and the parents, leading to (increased) variation. <p>B3.4 Sex determination:</p> <ol style="list-style-type: none"> Know that, in most mammals including humans, females are XX and males are XY. Analyse genetic data and diagrams to establish the sex and ratio of offspring
B4. Inheritance	T16 Inheritance	<p>B4.1 Know and understand the nucleus as a site of genetic material in eukaryotic cells. B4.2 Know and understand the following genetic terms:</p> <ol style="list-style-type: none"> gene allele dominant recessive heterozygous homozygous phenotype genotype chromosome autosome <p>B4.3 Monohybrid crosses:</p> <ol style="list-style-type: none"> Use and interpret genetic data and diagrams involving monohybrid (single gene) crosses. Use and interpret family trees/pedigrees and express outcomes as ratios, numbers, probabilities or percentages. Understand the concept of inherited conditions. Know that most phenotypes are the result of multiple genes and only some result from single gene inheritance.

ESAT Topic	CAIE Topic	NSAA Topic Details
B5. DNA	T6 Nucleic acids and protein synthesis	<p>B5.1 Know and understand that</p> <ol style="list-style-type: none"> the genome is the full set of genetic material (DNA) of an organism. this DNA is contained within chromosomes. <p>B5.2 Know and understand the structure of DNA:</p> <ol style="list-style-type: none"> Know and understand that single-stranded DNA (ssDNA) is a polymer made up of nucleotides joined together to form one strand of DNA. Know and understand that double-stranded DNA (dsDNA) is a polymer made up of two strands of DNA forming a double helix. Know and understand that the structure of each nucleotide consists of a common sugar and phosphate group as well as one of four different nitrogenous bases. Know the complementary pairs of DNA nitrogenous bases – adenine (A) pairs with thymine (T) and guanine (G) pairs with cytosine (C) – and that the sequence of these bases is the genetic code. <p>B5.3 Protein synthesis:</p> <ol style="list-style-type: none"> Know and understand that protein synthesis involves producing chains of amino acids called polypeptides. Know and understand that one or more polypeptide(s) can form a functional protein. Know and understand that the three-dimensional shape of a protein is determined by the sequence of its amino acids. Know and understand that the sequence of nucleotide bases in a gene determines the sequence of amino acids in the polypeptide the gene codes for. Know and understand that the sequence of nucleotides in a gene is 'read' as triplets, and that each triplet codes for an amino acid. <p>B5.4 Gene mutations:</p> <ol style="list-style-type: none"> Understand that a mutation changes the sequence of nucleotides in the DNA. Know that most mutations have no effect on the phenotype, some will have a small effect, whilst occasionally others will determine the phenotype.
B6. Gene technologies	T19 Genetic technology	<p>B6.1 Genetic engineering:</p> <ol style="list-style-type: none"> Understand the process of genetic engineering to include: <ol style="list-style-type: none"> taking a copy of a gene from the DNA of one organism insertion of that gene into the DNA of another organism the roles of restriction enzymes and ligases in recombining DNA. Recall and interpret examples of genetic engineering in different cell types. Explain the benefits and risks of using genetic engineering in medical applications. <p>B6.2 Stem cells:</p> <ol style="list-style-type: none"> Know and understand that some early embryonic cells are totipotent and have the potential to develop into a complete multicellular organism.

ESAT Topic	CAIE Topic	NSAA Topic Details
		<ul style="list-style-type: none"> b. Know and understand that most embryonic stem cells are pluripotent and can differentiate into any cell type. c. Know and understand that adult stem cells are multipotent and can differentiate into a limited number of different cell types. d. Know and understand the likely benefits and risks of using stem cells in medical applications. <p>B6.3 Selective breeding:</p> <ul style="list-style-type: none"> a. Know and understand the differences and similarities between natural selection and selective breeding. b. Understand the impact of selective breeding on populations.
B7. Variation	T17 Selection and evolution	<p>B7.1 Natural selection and evolution:</p> <ul style="list-style-type: none"> a. Know that there is usually extensive genetic variation within a population of a species. b. Describe evolution as a change in the inherited characteristics of a population over time through a process of natural selection which may result in the formation of a new species. c. Know and understand how evolution can occur through natural selection of variants that give rise to phenotypes best suited to their environment. d. Know and understand that antibiotic resistance in bacteria is an example of evolution through natural selection. <p>B7.2 Sources of variation:</p> <ul style="list-style-type: none"> a. Understand that variation can be genetic/inherited, resulting in a range of phenotypes. b. Understand that variation can also be environmental, which affects a range of phenotypes.
B8. Enzymes	T3 Enzymes	<p>B8.1 Know and understand that enzymes are primarily proteins that function as biological catalysts.</p> <p>B8.2 Know and understand the general mechanism of enzyme action, including the role of the active site and enzyme specificity.</p> <p>B8.3 Know and understand how the factors of temperature and pH can affect the rate of enzyme action.</p> <p>B8.4 Know the role of amylases, proteases and lipases in the digestion of carbohydrates, proteins and fats.</p>
B9. Animal physiology	12 Energy and respiration; T8 Transport in mammals; T9 Gas exchange; T15 Control and coordination; T14 Homeostasis; T10 Infectious diseases; T11 Immunity;	<p>B9.1 Respiration:</p> <ul style="list-style-type: none"> a. Know and understand the process of cellular respiration in living cells. b. Know and understand the process of aerobic respiration in living cells, including the word equation. c. Know and understand the process of anaerobic respiration in animal cells, including the word equation. <p>B9.2 Organ systems:</p> <ul style="list-style-type: none"> a. Nervous system: <ul style="list-style-type: none"> i. Know and understand that the central nervous system comprises the brain and

ESAT Topic	CAIE Topic	NSAA Topic Details
		<p>spinal cord.</p> <p>ii. Know and understand the structure and function of sensory neurones, relay neurones, motor neurones, synapses and the reflex arc.</p> <p>b. Respiratory system:</p> <p>i. Know and understand the structure and function of the respiratory (breathing) system, including the structure of the thorax.</p> <p>ii. Understand the processes of ventilation and gas exchange.</p> <p>iii. Know and understand the importance of a high surface area:volume ratio for the gas exchange process.</p> <p>c. Circulatory system:</p> <p>i. Know and understand the structure and function of the circulatory system, including the structure of the heart, characteristics of heart rate, ECGs, and the main types of blood vessel (arteries, veins and capillaries).</p> <p>ii. Know and understand the composition and function of the blood (red blood cells carry oxygen; white blood cells are involved in antibody production and phagocytosis; platelets are involved in blood clotting; and plasma is involved both in the transport of blood components and other dissolved substances including hormones, antibodies, urea and carbon dioxide, and in the distribution of heat).</p> <p>iii. Know and understand the relationship with the gaseous exchange system.</p> <p>iv. Know and understand the need for exchange surfaces and a transport system in multicellular organisms in terms of surface area:volume ratio.</p> <p>d. Digestive system:</p> <p>i. Know and understand the structure and function of the digestive system.</p> <p>ii. Know and understand the processes of peristalsis, digestion, absorption and egestion.</p> <p>e. Excretory system:</p> <p>iii. Know and understand the structure and function of the excretory system, including the kidney and the main components of the nephron.</p> <p>iv. Understand the role of the kidneys in homeostasis.</p> <p>B9.3 Homeostasis:</p> <p>a. Know that homeostasis is the maintenance of a constant internal environment, and appreciate its importance in multicellular animals.</p> <p>b. Understand the concept of negative feedback in the context of homeostasis.</p> <p>c. Know and understand the regulation of blood glucose levels, including the role of insulin and glucagon.</p> <p>d. Understand the main features of type 1 and type 2 diabetes, and how type 1 diabetes can be treated.</p> <p>e. Know and understand the regulation of water content (including the role of ADH) and the regulation of body temperature.</p> <p>B9.4 Hormones:</p> <p>a. Know and understand that hormones are released from specific endocrine glands and travel via the blood to their target structures.</p> <p>b. Know and understand the main role of adrenaline in the body.</p>

ESAT Topic	CAIE Topic	NSAA Topic Details
		<p>c. Know and understand the roles of hormones in human reproduction including:</p> <ol style="list-style-type: none"> those involved in the menstrual cycle (FSH, LH, oestrogen and progesterone). those used for contraception, and the differences between hormonal and non-hormonal forms of contraception. <p>B9.5 Disease and body defence:</p> <p>a. Communicable diseases:</p> <ol style="list-style-type: none"> Know that communicable diseases are caused by pathogenic bacteria, viruses, protists and fungi. Understand the transmission routes of sexually transmitted infections, including the effect on the immune system of HIV which results in AIDS. Understand the treatment of disease, including the use of antibiotics, vaccines (role of dead and inactive pathogens, antibody production and formation of memory cells) and techniques to prevent the spread of pathogens including HIV. Understand the process of discovery and development of new medicines and vaccines, including pre-clinical and clinical testing. <p>b. Non-communicable diseases:</p> <ol style="list-style-type: none"> Know that the following diseases are caused by the interaction of many factors: cardiovascular disease, many forms of cancer, some lung and liver diseases and diseases influenced by nutrition, including type 2 diabetes. Know that cardiovascular disease can be treated/managed using lifelong medication (including statins, anti-coagulants and anti-hypertensive drugs), surgical procedures (including stents and bypass for coronary heart disease), and lifestyle changes (including reducing smoking, more exercise and a balanced diet).
B10. Ecosystems	T18 Classification, biodiversity and conservation	<p>B10.1 Levels of organisation in an ecosystem:</p> <ol style="list-style-type: none"> Know and understand the organisation of levels within an ecosystem from individuals through to populations, and from communities through to ecosystems. Know and understand how communities can be affected by abiotic and biotic factors. Know and understand the factors that can cause a population to change in size. Understand the importance of interdependence in ecosystems (relating to predation, mutualism and parasitism) and of competition in a community. Know and understand that photosynthetic organisms are the primary producers of food in an ecosystem, and therefore biomass. <p>B10.2 Material cycling:</p> <ol style="list-style-type: none"> Know and understand the carbon cycle, including the importance of the following processes: <ol style="list-style-type: none"> photosynthesis respiration combustion decomposition Understand the importance of the water cycle to living organisms.

ESAT Topic	CAIE Topic	NSAA Topic Details
		<p>B10.3 Biodiversity:</p> <ol style="list-style-type: none"> Know and understand how quadrats and belt transects are used to investigate the distribution and abundance of organisms in a habitat, and interpret data from their use. Know and understand how to determine the number of organisms in a given area. Know and understand the positive and negative human interactions in an ecosystem, including fish farming, acid rain and eutrophication, and explain their impact on biodiversity.
B11. Plant physiology	T13 Photosynthesis; 7 Transport in plants	<p>B11.1 Importance of photosynthesis:</p> <ol style="list-style-type: none"> Know and understand the process of photosynthesis as an endothermic reaction that uses light energy to react carbon dioxide and water to produce glucose and oxygen. Understand the effect of temperature, light intensity and carbon dioxide concentration as limiting factors on the rate of photosynthesis. <p>B11.2 Transport systems in plants:</p> <ol style="list-style-type: none"> Know and understand how the structures of xylem and phloem are adapted to their functions in plants, including the role of: <ol style="list-style-type: none"> lignified dead cells in xylem tissue in the transport of water and mineral ions from the roots to the stems and leaves. living cells in phloem tissue in the transport of dissolved sugars from the leaves to the rest of the plant for immediate use or storage. Know and understand how water and mineral ions are taken up by plants, and relate the structure of root hair cells to their function in this. Know and understand the processes of transpiration and translocation, including the structure and function of the stomata. Know and understand the effect of environmental factors on the rate of water uptake by a plant, including light intensity, air movement, humidity and temperature. Calculate the rate of transpiration as: $\text{rate of transpiration} = \frac{\text{volume of water}}{\text{time taken}}$

Appendix: Admissions statistics for China, HK/TW & SG and all Internationals for 2019-22 entry⁴³

Applications, Offers and Acceptances by Domicile – ordered by year of entry, then by college

Entry Year	College	International (non-UK)				China				Hong Kong/Macao/Taiwan				Singapore			
		Apps.	Offers	Accept.	Success rate %	Apps.	Offers	Accept.	Success rate %	Apps.	Offers	Accept.	Success rate %	Apps.	Offers	Accept.	Success rate %
2019	Christ's	285	60	43	21	38	6	4	16	22	1	0	5	27	8	6	30
2019	Churchill	363	49	29	13	70	12	5	17	33	5	4	15	21	3	<3	14
2019	Clare	223	31	28	14	29	7	7	24	15	1	<3	7	14	1	<3	7
2019	Corpus Christi	200	27	19	14	41	3	<3	7	13	4	<3	31	15	1	<3	7
2019	Downing	246	30	26	12	53	7	7	13	25	3	3	12	14	1	<3	7
2019	Emmanuel	202	28	23	14	18	4	<3	22	28	5	4	18	15	4	4	27
2019	Fitzwilliam	194	33	24	17	70	17	14	24	18	1	<3	6	17	1	<3	6
2019	Girton	215	35	22	16	42	7	5	17	15	3	<3	20	9	5	4	56
2019	Gonville and Caius	289	40	35	14	37	5	4	14	27	3	3	11	18	1	<3	6
2019	Homerton	297	68	54	23	80	15	13	19	33	9	9	27	8	0	0	0
2019	Hughes Hall	131	47	30	36	<3	5	<3		5	1	<3	20	22	17	13	77
2019	Jesus	224	18	14	8	27	1	<3	4	22	5	5	23	11	1	0	9
2019	King's	375	32	23	9	51	5	3	10	26	1	<3	4	22	1	<3	5
2019	Lucy Cavendish	83	26	23	31	<3	1	<3		0	1	<3		3	1	<3	33
2019	Magdalene	216	37	25	17	55	13	9	24	32	6	5	19	20	4	4	20
2019	Murray Edwards	193	40	27	21	35	11	7	31	7	4	3	57	12	5	<3	42
2019	Newnham	190	37	30	19	53	8	6	15	14	1	<3	7	14	3	3	21
2019	Pembroke	247	32	22	13	35	3	<3	9	20	1	<3	5	14	1	<3	7
2019	Peterhouse	208	37	27	18	34	10	7	29	18	0	0	0	16	4	3	25
2019	Queens'	264	45	36	17	54	10	9	19	12	4	<3	33	15	3	3	20
2019	Robinson	217	31	25	14	58	14	11	24	27	3	<3	11	12	1	<3	8
2019	Selwyn	159	25	19	16	38	7	7	18	15	4	3	27	15	1	<3	7
2019	Sidney Sussex	159	30	28	19	28	4	4	14	13	1	<3	8	4	3	3	75
2019	St Catharine's	281	34	29	12	38	3	<3	8	26	1	<3	4	19	1	<3	5
2019	St Edmund's	117	36	27	31	9	1	0	11	7	1	<3	14	17	11	10	65
2019	St John's	372	58	42	16	66	7	7	11	35	9	7	26	24	4	3	17
2019	Trinity	627	99	77	16	80	16	13	20	31	7	3	23	34	1	<3	3
2019	Trinity Hall	155	27	16	17	17	4	<3	24	18	6	4	33	15	1	<3	7
2019	Wolfson	111	35	29	32	<3	1	<3		4	0	0	0	20	11	9	55
2019	Totals	6843	1127	852	18	1156	207	142	17	561	91	53	17	467	99	65	23

⁴³ https://www.whatdotheyknow.com/request/undergraduate_admission_statistics

Entry Year	College	International (non-UK)				China				Hong Kong/Macao/Taiwan				Singapore			
		Apps.	Offers	Accept.	Success rate %	Apps.	Offers	Accept.	Success rate %	Apps.	Offers	Accept.	Success rate %	Apps.	Offers	Accept.	Success rate %
2020	Christ's	305	61	44	20	61	11	7	18	14	4	4	29	22	9	5	41
2020	Churchill	391	65	36	17	78	21	11	27	33	4	3	12	31	1	<3	3
2020	Clare	206	31	23	15	39	6	6	15	27	1	<3	4	13	1	<3	8
2020	Corpus Christi	173	19	14	11	38	6	6	16	15	1	<3	7	18	1	<3	6
2020	Downing	237	36	30	15	40	6	5	15	47	7	5	15	22	5	4	23
2020	Emmanuel	192	27	20	14	25	6	5	24	15	1	<3	7	17	3	<3	18
2020	Fitzwilliam	216	36	26	17	96	21	16	22	22	1	<3	5	17	1	0	6
2020	Girton	254	43	32	17	66	8	5	12	25	4	4	16	10	1	<3	10
2020	Gonville and Caius	258	37	30	14	34	6	4	18	23	3	3	13	19	3	<3	16
2020	Homerton	332	62	47	19	113	23	18	20	35	4	<3	11	18	4	0	22
2020	Hughes Hall	149	46	33	31	10	4	3	40	10	4	3	40	22	19	15	86
2020	Jesus	198	20	14	10	33	3	<3	9	17	1	<3	6	7	1	0	14
2020	King's	357	47	36	13	34	7	4	21	21	6	5	29	26	1	<3	4
2020	Lucy Cavendish	69	21	18	30	<3	1	<3		3	0	<3	0	<3	1	<3	
2020	Magdalene	218	55	36	25	50	18	11	36	34	11	7	32	18	6	3	33
2020	Murray Edwards	197	26	15	13	49	7	6	14	4	3	3	75	15	4	<3	27
2020	Newnham	188	38	26	20	45	12	5	27	19	4	4	21	12	1	<3	8
2020	Pembroke	220	26	20	12	34	6	3	18	20	1	<3	5	10	1	0	10
2020	Peterhouse	191	40	34	21	40	9	8	23	20	5	5	25	8	1	<3	13
2020	Queens'	279	31	23	11	54	11	9	20	23	4	3	17	11	1	<3	9
2020	Robinson	219	32	24	15	77	13	9	17	22	1	<3	5	5	1	<3	20
2020	Selwyn	176	29	28	16	47	9	8	19	22	5	6	23	11	1	<3	9
2020	Sidney Sussex	205	27	17	13	53	8	7	15	14	1	<3	7	6	1	<3	17
2020	St Catharine's	255	33	28	13	47	7	5	15	22	4	4	18	25	5	5	20
2020	St Edmund's	107	26	20	24	7	4	<3	57	3	1	<3	33	11	11	9	100
2020	St John's	453	49	38	11	38	6	4	16	35	8	8	23	18	4	<3	22
2020	Trinity	660	97	72	15	85	17	14	20	30	9	8	30	44	10	5	23
2020	Trinity Hall	182	24	20	13	35	9	9	26	16	3	<3	19	12	1	3	8
2020	Wolfson	86	26	23	30	<3	1	<3		<3	0	0		14	6	6	43
2020	Totals	6973	1110	827	17	1328	266	188	21	591	101	75	19	462	105	55	22

Entry Year	College	International (non-UK)				China				Hong Kong/Macao/Taiwan				Singapore			
		Apps.	Offers	Accept.	Success rate %	Apps.	Offers	Accept.	Success rate %	Apps.	Offers	Accept.	Success rate %	Apps.	Offers	Accept.	Success rate %
2021	Christ's	365	54	38	15	66	13	8	20	31	5	4	16	36	8	6	22
2021	Churchill	448	48	30	11	143	16	11	11	39	6	4	15	31	1	<3	3
2021	Clare	257	25	20	10	55	8	7	15	18	3	3	17	17	0	0	0
2021	Corpus Christi	224	23	21	10	52	9	9	17	20	3	<3	15	20	3	3	15
2021	Downing	291	27	25	9	60	9	9	15	46	5	5	11	28	3	3	11
2021	Emmanuel	195	22	15	11	54	6	4	11	17	4	3	24	11	3	3	27
2021	Fitzwilliam	295	43	34	15	131	25	20	19	24	3	3	13	28	4	4	14
2021	Girton	265	29	19	11	89	10	7	11	20	3	<3	15	11	1	0	9
2021	Gonville and Caius	284	31	24	11	70	6	6	9	25	1	<3	4	16	0	0	0
2021	Homerton	423	60	48	14	200	27	21	14	46	5	5	11	18	1	<3	6
2021	Hughes Hall	168	60	37	36	10	7	3	70	7	6	4	86	22	20	14	91
2021	Jesus	210	21	15	10	40	1	0	3	20	1	<3	5	11	1	<3	9
2021	King's	388	38	26	10	53	5	3	9	11	1	<3	9	24	1	<3	4
2021	Lucy Cavendish	167	65	46	39	43	9	8	21	14	6	5	43	<3	11	6	
2021	Magdalene	250	33	19	13	73	12	7	16	41	6	6	15	19	6	3	32
2021	Murray Edwards	219	27	20	12	76	10	9	13	8	1	<3	13	9	4	3	44
2021	Newnham	185	30	24	16	58	11	9	19	9	1	<3	11	7	1	0	14
2021	Pembroke	264	24	17	9	50	8	4	16	28	4	<3	14	16	0	0	0
2021	Peterhouse	210	38	25	18	48	6	4	13	20	5	4	25	9	1	<3	11
2021	Queens'	308	34	23	11	74	6	5	8	33	6	4	18	18	3	3	17
2021	Robinson	266	30	26	11	111	16	15	14	30	3	3	10	10	1	0	10
2021	Selwyn	204	22	16	11	75	8	6	11	18	3	3	17	12	1	0	8
2021	Sidney Sussex	194	21	18	11	67	7	6	10	18	0	0	0	9	1	<3	11
2021	St Catharine's	271	25	23	9	80	9	7	11	31	1	<3	3	20	3	<3	15
2021	St Edmund's	122	51	35	42	7	3	0	43	6	1	<3	17	13	23	17	177
2021	St John's	441	39	31	9	65	7	7	11	45	6	6	13	35	4	<3	11
2021	Trinity	718	108	77	15	94	21	15	22	31	5	5	16	53	12	10	23
2021	Trinity Hall	194	23	17	12	46	5	4	11	22	5	5	23	12	1	<3	8
2021	Wolfson	136	37	31	27	9	4	3	44	8	1	<3	13	18	11	9	61
2021	Totals	7962	1088	800	15	1999	284	217	17	686	100	72	17	533	129	84	23

Entry Year	College	International (non-UK)				China				Hong Kong/Macao/Taiwan				Singapore			
		Apps.	Offers	Accept.	Success rate %	Apps.	Offers	Accept.	Success rate %	Apps.	Offers	Accept.	Success rate %	Apps.	Offers	Accept.	Success rate %
2022	Christ's	369	60	47	16	83	13	9	16	20	1	<3	5	55	11	9	20
2022	Churchill	428	38	32	9	116	9	7	8	35	4	4	11	37	6	5	16
2022	Clare	249	24	17	10	53	7	7	13	21	3	<3	14	10	1	<3	10
2022	Corpus Christi	209	20	15	10	67	6	4	9	17	1	<3	6	14	1	<3	7
2022	Downing	248	28	20	11	38	3	4	8	35	6	7	17	26	4	3	15
2022	Emmanuel	253	29	26	11	60	6	5	10	24	5	5	21	24	3	3	13
2022	Fitzwilliam	327	29	27	9	167	14	13	8	11	1	<3	9	29	3	3	10
2022	Girton	220	26	19	12	109	14	10	13	20	5	4	25	9	0	0	0
2022	Gonville and Caius	240	25	19	10	58	5	4	9	23	0	0	0	20	1	0	5
2022	Homerton	462	62	47	13	227	26	22	11	36	4	3	11	22	8	6	36
2022	Hughes Hall	150	59	38	39	7	6	4	86	6	4	3	67	22	22	18	100
2022	Jesus	206	17	14	8	34	1	<3	3	13	1	<3	8	14	0	0	0
2022	King's	336	26	22	8	54	1	<3	2	19	1	<3	5	25	5	5	20
2022	Lucy Cavendish	226	61	40	27	91	18	11	20	18	4	<3	22	4	9	8	225
2022	Magdalene	263	37	25	14	96	17	13	18	34	6	5	18	20	1	<3	5
2022	Murray Edwards	156	26	14	17	84	16	8	19	6	1	<3	17	3	3	<3	100
2022	Newnham	197	26	22	13	70	13	10	19	14	4	3	29	13	1	<3	8
2022	Pembroke	238	25	17	11	50	4	3	8	24	4	3	17	27	3	<3	11
2022	Peterhouse	218	37	25	17	48	7	6	15	22	1	<3	5	18	3	<3	17
2022	Queens'	343	37	28	11	91	12	8	13	24	1	<3	4	23	6	6	26
2022	Robinson	241	29	22	12	110	14	11	13	25	5	3	20	10	0	0	0
2022	Selwyn	218	33	26	15	84	12	8	14	18	4	3	22	15	3	<3	20
2022	Sidney Sussex	177	25	20	14	70	9	7	13	20	5	4	25	12	1	<3	8
2022	St Catharine's	291	24	17	8	81	11	10	14	39	1	<3	3	28	3	<3	11
2022	St Edmund's	97	38	31	39	10	3	<3	30	7	1	0	14	16	14	15	88
2022	St John's	357	46	31	13	65	15	11	23	40	8	5	20	27	6	3	22
2022	Trinity	644	107	69	17	82	22	19	27	27	5	4	19	59	13	7	22
2022	Trinity Hall	213	14	11	7	71	5	7	7	19	3	<3	16	10	1	<3	10
2022	Wolfson	103	34	30	33	5	5	4	100	0	1	<3		23	13	12	57
2022	Totals	7679	1042	771	15	2181	294	225	19	617	90	56	16	615	145	103	30

Appendix: Applications, Offers etc by Domicile – ordered by success rate for non-UK students

Entry Year	College	International (non-UK)				China				Hong Kong/Macao/Taiwan				Singapore			
		Apps.	Offers	Accept.	Success rate %	Apps.	Offers	Accept.	Success rate %	Apps.	Offers	Accept.	Success rate %	Apps.	Offers	Accept.	Success rate %
2019	Totals	6843	1127	852	18	1156	207	142	17	561	91	53	17	467	99	65	23
2020	Totals	6973	1110	827	17	1328	266	188	21	591	101	75	19	462	105	55	22
2021	Totals	7962	1088	800	15	1999	284	217	17	686	100	72	17	533	129	84	23
2022	Totals	7679	1042	771	15	2181	294	225	19	617	90	56	16	615	145	103	30
2021	St Edmund's	122	51	35	42	7	3	0	43	6	1	<3	17	13	23	17	177
2021	Lucy Cavendish	167	65	46	39	43	9	8	21	14	6	5	43	<3	11	6	
2022	Hughes Hall	150	59	38	39	7	6	4	86	6	4	3	67	22	22	18	100
2022	St Edmund's	97	38	31	39	10	3	<3	30	7	1	0	14	16	14	15	88
2019	Hughes Hall	131	47	30	36	<3	5	<3		5	1	<3	20	22	17	13	77
2021	Hughes Hall	168	60	37	36	10	7	3	70	7	6	4	86	22	20	14	91
2022	Wolfson	103	34	30	33	5	5	4	100	0	1	<3		23	13	12	57
2019	Wolfson	111	35	29	32	<3	1	<3		4	0	0	0	20	11	9	55
2019	Lucy Cavendish	83	26	23	31	<3	1	<3		0	1	<3		3	1	<3	33
2019	St Edmund's	117	36	27	31	9	1	0	11	7	1	<3	14	17	11	10	65
2020	Hughes Hall	149	46	33	31	10	4	3	40	10	4	3	40	22	19	15	86
2020	Lucy Cavendish	69	21	18	30	<3	1	<3		3	0	<3	0	<3	1	<3	
2020	Wolfson	86	26	23	30	<3	1	<3		<3	0	0		14	6	6	43
2021	Wolfson	136	37	31	27	9	4	3	44	8	1	<3	13	18	11	9	61
2022	Lucy Cavendish	226	61	40	27	91	18	11	20	18	4	<3	22	4	9	8	225
2020	Magdalene	218	55	36	25	50	18	11	36	34	11	7	32	18	6	3	33
2020	St Edmund's	107	26	20	24	7	4	<3	57	3	1	<3	33	11	11	9	100
2019	Homerton	297	68	54	23	80	15	13	19	33	9	9	27	8	0	0	0
2019	Christ's	285	60	43	21	38	6	4	16	22	1	0	5	27	8	6	30
2019	Murray Edwards	193	40	27	21	35	11	7	31	7	4	3	57	12	5	<3	42
2020	Peterhouse	191	40	34	21	40	9	8	23	20	5	5	25	8	1	<3	13
2020	Christ's	305	61	44	20	61	11	7	18	14	4	4	29	22	9	5	41
2020	Newnham	188	38	26	20	45	12	5	27	19	4	4	21	12	1	<3	8
2019	Newnham	190	37	30	19	53	8	6	15	14	1	<3	7	14	3	3	21
2019	Sidney Sussex	159	30	28	19	28	4	4	14	13	1	<3	8	4	3	3	75

Entry Year	College	International (non-UK)				China				Hong Kong/Macao/Taiwan				Singapore			
		Apps.	Offers	Accept.	Success rate %	Apps.	Offers	Accept.	Success rate %	Apps.	Offers	Accept.	Success rate %	Apps.	Offers	Accept.	Success rate %
2020	Homerton	332	62	47	19	113	23	18	20	35	4	<3	11	18	4	0	22
2019	Peterhouse	208	37	27	18	34	10	7	29	18	0	0	0	16	4	3	25
2021	Peterhouse	210	38	25	18	48	6	4	13	20	5	4	25	9	1	<3	11
2019	Fitzwilliam	194	33	24	17	70	17	14	24	18	1	<3	6	17	1	<3	6
2019	Magdalene	216	37	25	17	55	13	9	24	32	6	5	19	20	4	4	20
2019	Queens'	264	45	36	17	54	10	9	19	12	4	<3	33	15	3	3	20
2019	Trinity Hall	155	27	16	17	17	4	<3	24	18	6	4	33	15	1	<3	7
2020	Churchill	391	65	36	17	78	21	11	27	33	4	3	12	31	1	<3	3
2020	Fitzwilliam	216	36	26	17	96	21	16	22	22	1	<3	5	17	1	0	6
2020	Girton	254	43	32	17	66	8	5	12	25	4	4	16	10	1	<3	10
2022	Murray Edwards	156	26	14	17	84	16	8	19	6	1	<3	17	3	3	<3	100
2022	Peterhouse	218	37	25	17	48	7	6	15	22	1	<3	5	18	3	<3	17
2022	Trinity	644	107	69	17	82	22	19	27	27	5	4	19	59	13	7	22
2019	Girton	215	35	22	16	42	7	5	17	15	3	<3	20	9	5	4	56
2019	Selwyn	159	25	19	16	38	7	7	18	15	4	3	27	15	1	<3	7
2019	St John's	372	58	42	16	66	7	7	11	35	9	7	26	24	4	3	17
2019	Trinity	627	99	77	16	80	16	13	20	31	7	3	23	34	1	<3	3
2020	Selwyn	176	29	28	16	47	9	8	19	22	5	6	23	11	1	<3	9
2021	Newnham	185	30	24	16	58	11	9	19	9	1	<3	11	7	1	0	14
2022	Christ's	369	60	47	16	83	13	9	16	20	1	<3	5	55	11	9	20
2020	Clare	206	31	23	15	39	6	6	15	27	1	<3	4	13	1	<3	8
2020	Downing	237	36	30	15	40	6	5	15	47	7	5	15	22	5	4	23
2020	Robinson	219	32	24	15	77	13	9	17	22	1	<3	5	5	1	<3	20
2020	Trinity	660	97	72	15	85	17	14	20	30	9	8	30	44	10	5	23
2021	Christ's	365	54	38	15	66	13	8	20	31	5	4	16	36	8	6	22
2021	Fitzwilliam	295	43	34	15	131	25	20	19	24	3	3	13	28	4	4	14
2021	Trinity	718	108	77	15	94	21	15	22	31	5	5	16	53	12	10	23
2022	Selwyn	218	33	26	15	84	12	8	14	18	4	3	22	15	3	<3	20
2019	Clare	223	31	28	14	29	7	7	24	15	1	<3	7	14	1	<3	7
2019	Corpus Christi	200	27	19	14	41	3	<3	7	13	4	<3	31	15	1	<3	7
2019	Emmanuel	202	28	23	14	18	4	<3	22	28	5	4	18	15	4	4	27
2019	Gonville and Caius	289	40	35	14	37	5	4	14	27	3	3	11	18	1	<3	6

Entry Year	College	International (non-UK)				China				Hong Kong/Macao/Taiwan				Singapore			
		Apps.	Offers	Accept.	Success rate %	Apps.	Offers	Accept.	Success rate %	Apps.	Offers	Accept.	Success rate %	Apps.	Offers	Accept.	Success rate %
2019	Robinson	217	31	25	14	58	14	11	24	27	3	<3	11	12	1	<3	8
2020	Emmanuel	192	27	20	14	25	6	5	24	15	1	<3	7	17	3	<3	18
2020	Gonville and Caius	258	37	30	14	34	6	4	18	23	3	3	13	19	3	<3	16
2021	Homerton	423	60	48	14	200	27	21	14	46	5	5	11	18	1	<3	6
2022	Magdalene	263	37	25	14	96	17	13	18	34	6	5	18	20	1	<3	5
2022	Sidney Sussex	177	25	20	14	70	9	7	13	20	5	4	25	12	1	<3	8
2019	Churchill	363	49	29	13	70	12	5	17	33	5	4	15	21	3	<3	14
2019	Pembroke	247	32	22	13	35	3	<3	9	20	1	<3	5	14	1	<3	7
2020	King's	357	47	36	13	34	7	4	21	21	6	5	29	26	1	<3	4
2020	Murray Edwards	197	26	15	13	49	7	6	14	4	3	3	75	15	4	<3	27
2020	Sidney Sussex	205	27	17	13	53	8	7	15	14	1	<3	7	6	1	<3	17
2020	St Catharine's	255	33	28	13	47	7	5	15	22	4	4	18	25	5	5	20
2020	Trinity Hall	182	24	20	13	35	9	9	26	16	3	<3	19	12	1	3	8
2021	Magdalene	250	33	19	13	73	12	7	16	41	6	6	15	19	6	3	32
2022	Homerton	462	62	47	13	227	26	22	11	36	4	3	11	22	8	6	36
2022	Newnham	197	26	22	13	70	13	10	19	14	4	3	29	13	1	<3	8
2022	St John's	357	46	31	13	65	15	11	23	40	8	5	20	27	6	3	22
2019	Downing	246	30	26	12	53	7	7	13	25	3	3	12	14	1	<3	7
2019	St Catharine's	281	34	29	12	38	3	<3	8	26	1	<3	4	19	1	<3	5
2020	Pembroke	220	26	20	12	34	6	3	18	20	1	<3	5	10	1	0	10
2021	Murray Edwards	219	27	20	12	76	10	9	13	8	1	<3	13	9	4	3	44
2021	Trinity Hall	194	23	17	12	46	5	4	11	22	5	5	23	12	1	<3	8
2022	Girton	220	26	19	12	109	14	10	13	20	5	4	25	9	0	0	0
2022	Robinson	241	29	22	12	110	14	11	13	25	5	3	20	10	0	0	0
2020	Corpus Christi	173	19	14	11	38	6	6	16	15	1	<3	7	18	1	<3	6
2020	Queens'	279	31	23	11	54	11	9	20	23	4	3	17	11	1	<3	9
2020	St John's	453	49	38	11	38	6	4	16	35	8	8	23	18	4	<3	22
2021	Churchill	448	48	30	11	143	16	11	11	39	6	4	15	31	1	<3	3
2021	Emmanuel	195	22	15	11	54	6	4	11	17	4	3	24	11	3	3	27
2021	Girton	265	29	19	11	89	10	7	11	20	3	<3	15	11	1	0	9
2021	Gonville and Caius	284	31	24	11	70	6	6	9	25	1	<3	4	16	0	0	0

Entry Year	College	International (non-UK)				China				Hong Kong/Macao/Taiwan				Singapore			
		Apps.	Offers	Accept.	Success rate %	Apps.	Offers	Accept.	Success rate %	Apps.	Offers	Accept.	Success rate %	Apps.	Offers	Accept.	Success rate %
2021	Queens'	308	34	23	11	74	6	5	8	33	6	4	18	18	3	3	17
2021	Robinson	266	30	26	11	111	16	15	14	30	3	3	10	10	1	0	10
2021	Selwyn	204	22	16	11	75	8	6	11	18	3	3	17	12	1	0	8
2021	Sidney Sussex	194	21	18	11	67	7	6	10	18	0	0	0	9	1	<3	11
2022	Downing	248	28	20	11	38	3	4	8	35	6	7	17	26	4	3	15
2022	Emmanuel	253	29	26	11	60	6	5	10	24	5	5	21	24	3	3	13
2022	Pembroke	238	25	17	11	50	4	3	8	24	4	3	17	27	3	<3	11
2022	Queens'	343	37	28	11	91	12	8	13	24	1	<3	4	23	6	6	26
2020	Jesus	198	20	14	10	33	3	<3	9	17	1	<3	6	7	1	0	14
2021	Clare	257	25	20	10	55	8	7	15	18	3	3	17	17	0	0	0
2021	Corpus Christi	224	23	21	10	52	9	9	17	20	3	<3	15	20	3	3	15
2021	Jesus	210	21	15	10	40	1	0	3	20	1	<3	5	11	1	<3	9
2021	King's	388	38	26	10	53	5	3	9	11	1	<3	9	24	1	<3	4
2022	Clare	249	24	17	10	53	7	7	13	21	3	<3	14	10	1	<3	10
2022	Corpus Christi	209	20	15	10	67	6	4	9	17	1	<3	6	14	1	<3	7
2022	Gonville and Caius	240	25	19	10	58	5	4	9	23	0	0	0	20	1	0	5
2019	King's	375	32	23	9	51	5	3	10	26	1	<3	4	22	1	<3	5
2021	Downing	291	27	25	9	60	9	9	15	46	5	5	11	28	3	3	11
2021	Pembroke	264	24	17	9	50	8	4	16	28	4	<3	14	16	0	0	0
2021	St Catharine's	271	25	23	9	80	9	7	11	31	1	<3	3	20	3	<3	15
2021	St John's	441	39	31	9	65	7	7	11	45	6	6	13	35	4	<3	11
2022	Churchill	428	38	32	9	116	9	7	8	35	4	4	11	37	6	5	16
2022	Fitzwilliam	327	29	27	9	167	14	13	8	11	1	<3	9	29	3	3	10
2019	Jesus	224	18	14	8	27	1	<3	4	22	5	5	23	11	1	0	9
2022	Jesus	206	17	14	8	34	1	<3	3	13	1	<3	8	14	0	0	0
2022	King's	336	26	22	8	54	1	<3	2	19	1	<3	5	25	5	5	20
2022	St Catharine's	291	24	17	8	81	11	10	14	39	1	<3	3	28	3	<3	11
2022	Trinity Hall	213	14	11	7	71	5	7	7	19	3	<3	16	10	1	<3	10

Appendix: Changes to the Natural Sciences Entrance Requirements webpage through time

Comparing 2016 with 2020 versions of the website:

<https://web.archive.org/web/20200811000352/https://www.undergraduate.study.cam.ac.uk/courses/natural-sciences>

“Changes to the assessment format

Please be aware that Section 2 Biology was updated in 2022. Section 2 Biology now tests knowledge of advanced topics, bringing it in line with Section 2 Physics and Chemistry. You should take this into consideration when looking at past papers.(2023)”⁴⁴

“A specimen paper has been produced to allow you to sample the written assessment format and practice under timed conditions. It is not expected that you will answer every question correctly; the written assessment is designed to be challenging. Even some strong candidates may not complete the paper in the time allowed; it is designed to distinguish across our field of high-calibre applicants.

Experience with similar assessments and from trials indicates that, on average, typical applicants to the most highly selective undergraduate courses (who are by definition academically very able) will gain approximately half of the available marks. The best applicants will score more highly, but only relatively few are expected to gain more than 80% of the available marks.

Written assessments help admissions tutors to assess whether candidates have the skills, aptitudes and any required subject knowledge and understanding required to study the relevant course at Cambridge. They are only one of the elements used in the admissions process. Others include a candidate’s academic record and forecast grades in school-leaving examinations; UCAS application form; examples of recent written work submitted to the College to which they are applying; and performance at interview, if invited to attend.”⁴⁵

Comparing two versions of the Entrance Requirements from 03/08/2016⁴⁶ (differences highlighted green) and 21/03/2021⁴⁷ (differences highlighted in red)

<https://web.archive.org/web/20210323162554/https://www.undergraduate.study.cam.ac.uk/courses/natural-sciences>

For further information about studying Natural Sciences at the University of Cambridge see the Natural Sciences Tripos website.
Typical offers **and requirements** require
A Level: A*A*A
IB: **40-42** **40-41** points, with 776 at Higher Level
Other qualifications: See For other qualifications, see our **main** Entrance requirements **and International qualifications.**
Science/mathematics pages.
Course requirements
Please note that in the following 'science/mathematics' subjects' refers to Biology, Chemistry, Physics, Mathematics and Further Mathematics. It does not include Psychology.
Required by all **Colleges: A** **Colleges: A** Levels/IB Higher Levels in at least two science/mathematics, see also **the Part IA paper descriptions for specific** subject requirements for **the** Year 1 options
Required by some Colleges: AS or A Level/IB Standard or Higher Level in a third science/mathematics subject and/or particular **subjects**

⁴⁴ From: <https://www.undergraduate.study.cam.ac.uk/apply/how/natural-sciences-admission-test> (accessed September 2023)

⁴⁵ <https://web.archive.org/web/20160828130710/https://www.undergraduate.study.cam.ac.uk/courses/natural-sciences#entry-requirements>

⁴⁶ <https://web.archive.org/web/20160803045320/http://www.undergraduate.study.cam.ac.uk/courses/natural-sciences>

⁴⁷ <https://web.archive.org/web/20210323162554/https://www.undergraduate.study.cam.ac.uk/courses/natural-sciences>
www.SmashingScience.org



Other examination systems

We expect applicants taking other recognised qualifications to have a level of understanding in science and mathematics roughly equivalent to those applying with A Levels.

Refer to our main Entrance requirements pages and consult a College Admissions Tutor for further advice.

Admission assessment

For 2022 entry, all All applicants for Natural Sciences (including applicants to mature Colleges) are required to take a the pre-interview written assessment in early November 2021, for Natural Sciences at an authorised centre local to them (for a lot of applicants, this will be their school/college).

Please see the Cambridge Admissions Testing website for information about registration deadlines, and check admission assessments for further details.

Assessment format

The format for the 2021 assessment will be as follows:

Section 1: Multiple choice questions in mathematics plus one science (Biology, Chemistry or Physics) (60 1 content

Maths and Science MCQs (80 minutes)

Section 2: Extended multiple choice 2 content

Science-specific longer questions in Biology, Chemistry or Physics (60 (40 minutes)

PDF icon Natural Sciences Admissions Assessment Specification 2021 Specification

You must be registered in advance (separately to your UCAS application) to take the assessment – the registration deadline is 15 October 2016. Your assessment centre must register you for the pre-interview assessment; you're not able to register yourself. See the written assessments page for information about assessment centres and registration.

The pre-interview written assessment for Natural Sciences will be taken on 2 November 2016. Please check the Admissions Testing Service website for scheduled start times.

Please note that your performance in the pre-interview assessment will not be considered in isolation, but will be taken into account alongside the other elements of your application.

In addition to the pre-interview assessment, applicants who are invited to the following Colleges interview are required to take a College-set written assessment at interview at the following Colleges (see individual College websites for details):

Magdalene

St John's

Trinity

Mature students (aged 21 or over) applying to one of the mature Colleges should refer to the relevant information about pre-interview assessments on the written assessments page.

Specimen and past papers

A specimen paper has been produced to allow you to sample the written assessment format and practice under timed conditions. It is not expected that you will answer every question correctly; the written assessment is designed to be challenging. Even some strong candidates may not complete the paper in the time allowed; it is designed to distinguish across our field of high-calibre applicants.

Experience with similar assessments and from trials indicates that, on average, typical applicants to the most highly selective undergraduate courses (who are by definition academically very able) will gain approximately half of the available marks. The best applicants will score more highly, but only relatively few are expected to gain more than 80 per cent 80% of the available marks.

Comparing 21/03/2021⁴⁸ (red highlighted) with 02/06/22⁴⁹ (green highlighted)

Required: a laptop – cost if purchased new will depend on choice, but existing laptops if less than four years old are likely to be completely adequate for the course needs.

Optional: textbooks (available in libraries), specialist equipment (can be borrowed)

Optional – for Part IA Evolution and Behaviour: field course – Estimated cost £65 £50 + travel

Years 2, 3 and 4

Required and optional additional costs are dependent on the options taken

Information about additional costs is available on the Natural Sciences website. Refer to the individual Departments' websites for further details.

Changing course

In the first year, a number of students take Mathematics with Physics and then change to Natural Sciences to continue with Physics from their second year.

In contrast, some students take Part IA Natural Sciences and change to the Computer Science course or Chemical Engineering in their second year. It's also possible

Entry Requirements

This page details the standard entry requirements for this course. However, variations may exist between Colleges and you should check the documents below for details:

PDF icon Natural Sciences (Biological) entry requirements by College for 2023 entry (these are subject to change and will be finalised by early July 2022).

PDF icon Natural Sciences (Physical) entry requirements by College for 2023 entry (these are subject to change and will be finalised by early July 2022).

Typical offers and requirements require

A Level: A*A*A

IB: 40-42 points, with 776 at Higher Level

⁴⁸ <https://web.archive.org/web/20210323162554/https://www.undergraduate.study.cam.ac.uk/courses/natural-sciences>

⁴⁹ <https://web.archive.org/web/20220602102835/https://www.undergraduate.study.cam.ac.uk/courses/natural-sciences>

Admission assessment

For 2022 entry, all All applicants for Natural Sciences (including applicants to mature Colleges) are required to take a pre-interview written assessment in early November 2021, the Natural Sciences Admissions Assessment (NSAA) at an authorised assessment centre local to them (for a lot of applicants, this will (usually your school or college), for which you must be their school/college), registered in advance.

Please see the Cambridge Admissions Testing website for information about dates and registration deadlines, and check admission assessments for further details. Assessment format

The NSAA Section 2 Biology component is being updated for 2022. From November 2022, Section 2 Biology will assume knowledge of advanced topics. This brings it in line with Section 2 Physics and Chemistry, which already assume knowledge of advanced topics. The topics to be included will be detailed in an updated test specification, to be published here in May 2022 together with a revised specimen question paper and explained answers.

The NSAA format for the 2021 assessment will be as follows:

Section 1: Multiple choice questions in mathematics plus one science (Biology, Chemistry or Physics) (60 minutes)

Section 2: Extended multiple choice questions in Biology, Chemistry or Physics (60 minutes)

PDF icon Natural Sciences Admissions Assessment Specification 2021

Please note that your performance in the pre-interview assessment will not be considered in isolation, but will be taken into account alongside the other elements of your application.

In addition to the pre-interview assessment, addition, applicants to the following some Colleges are may be required to take a College-set written assessment at interview (see individual College websites for details):

Magdalene
Trinity details).

Specimen and past papers

A specimen paper has been produced to allow you to sample the written assessment format and practice under timed conditions. It is not expected that you will answer every question correctly; the written assessment is designed to be challenging. Even some strong candidates may not complete the paper in the time allowed; it is designed to distinguish across our field of high-calibre applicants.

Experience with similar assessments and from trials indicates that, on average, typical applicants to the most highly selective undergraduate courses (who are by definition academically very able) will gain approximately half of the available marks. The best applicants will score more highly, but only relatively few are expected to gain more than 80 per cent of the available marks.

Written assessments help admissions tutors to assess whether candidates have the skills, aptitudes and any required subject knowledge and understanding required to study the relevant course at Cambridge. They are only one of the elements used in the admissions process. Others include a candidate's academic record and forecast grades in school-leaving examinations; UCAS application form; examples of recent written work submitted to the College to which they are applying; and performance at interview, if invited to attend.

Comparing 30/04/23⁵⁰ (green highlights) with 02/06/22⁵¹ (red highlighted)

Subject requirements

'Science/mathematics subjects' refers to Biology, Chemistry, Physics, Mathematics and Further Mathematics. It does not include Psychology.

Required by all Colleges: All Colleges require: A Level/IB Higher Level Mathematics and A Levels/IB Higher Levels in at least two science/mathematics, other science subjects, see also subject requirements for Year 1 options

Required by some Colleges: AS or A Level/IB Standard or Higher Level in a third Further guidance: In exceptional circumstances, applicants with only two science/mathematics subject and/or particular subjects

PDF icon Natural subjects and Biological Sciences (Biological): Subject Requirements and Typical Offer by College

PDF icon Natural Sciences (Physical): Subject Requirements and Typical Offer by College

All undergraduate admissions decisions are the responsibility of the Cambridge Colleges. Please contact the relevant College admissions office if you have any queries about College-specific requirements. applicants without Mathematics may be considered.

See Entrance requirements and PDF icon The Subject Matters Choosing your post-16 subjects for additional advice about general requirements for entry, qualifications guidance and offers. conditions of entry.

A Levels

Most students have Your subject choices at least three science/mathematics A Levels. The minimum requirement is two, but this will Level may restrict your choice of Part IA options. In these circumstances, you'll normally be expected to achieve A* in both of the science/mathematics subjects and encouraged to take an additional science/mathematics AS Level. subject choice. The more useful subject combinations are:

A Level Biology, A Level Chemistry, and AS Level Mathematics or Physics

A Level Chemistry, A Level Mathematics, Mathematics and AS A Level Biology or Physics

A Level Physics, A Level Mathematics and AS A Level Further Mathematics

If you don't have A Level Mathematics, you're required to complete some preparatory work before the start of the course Biology, A Level Chemistry and must take Mathematical Biology as your mathematics subject in Year 1. A Level Mathematics

International Baccalaureate

The advice above about A Level subject combinations also applies to the IB. For these purposes:

Standard Level subjects will satisfy AS Level subject requirements. IB.

Higher Level subjects will satisfy A Level subject requirements

IB For Natural Sciences (Physical), if taking Higher Level Mathematics, applicants are expected to take IB Higher Level 'Analysis Analysis and Approaches' for any course where Mathematics is a requirement. Approaches. If this option is not available at your school, please contact the College that you wish to apply to directly for further advice and guidance.

For Natural Sciences (Biological), if taking Higher Level Mathematics, we recommend Analysis and Approaches for the most competitive application, however Applications and Interpretations will also be considered.

⁵⁰ <https://web.archive.org/web/20230430054945/https://www.undergraduate.study.cam.ac.uk/courses/natural-sciences>

⁵¹ <https://web.archive.org/web/20220602102835/https://www.undergraduate.study.cam.ac.uk/courses/natural-sciences>
www.SmashingScience.org



Admission assessment

For 2022 entry, all All applicants for Natural Sciences (including applicants to mature Colleges) are required to take a pre-interview written assessment in early November 2021, the Natural Sciences Admissions Assessment (NSAA) at an authorised assessment centre local to them (for a lot of applicants, this will (usually your school or college), for which you must be their school/college), registered in advance.

Please see the Cambridge Admissions Testing website for information about dates and registration deadlines, and check admission assessments for further details.

Assessment format

The format NSAA Section 2 Biology component is being updated for the 2021 assessment 2022. From November 2022, Section 2 Biology will be as follows: assume knowledge of advanced topics, bringing it in line with Section 2 Physics and Chemistry, which already assume knowledge of advanced topics. See the updated specification document and specimen papers below for details.

PDF icon Natural Sciences Admissions Assessment Specification 2022

Section 1: Multiple choice questions in mathematics plus one science (Biology, Chemistry or Physics) (60 minutes)

Section 2: Extended multiple choice questions in Biology, Chemistry or Physics (60 minutes)

PDF icon Natural Sciences Admissions Assessment Specification 2021

Please note that your performance in the pre-interview assessment will not be considered in isolation, but will be taken into account alongside the other elements of your application.

In addition to the pre-interview assessment, applicants to the following Colleges are required to take a College-set written assessment at interview (see individual College websites for details):

Magdalene

Trinity

Specimen and past papers

A specimen paper has been produced to allow you to sample the written assessment format and practice under timed conditions. It is not expected that you will answer every question correctly; the written assessment is designed to be challenging. Even some strong candidates may not complete the paper in the time allowed; it is designed to distinguish across our field of high-calibre applicants.

Experience with similar assessments and from trials indicates that, on average, typical applicants to the most highly selective undergraduate courses (who are by definition academically very able) will gain approximately half of the available marks. The best applicants will score more highly, but only relatively few are expected to gain more than 80 per cent of the available marks.

Written assessments help admissions tutors to assess whether candidates have the skills, aptitudes and any required subject knowledge and understanding required to study the relevant course at Cambridge. They are only one of the elements used in the admissions process. Others include a candidate's academic record and forecast grades in school-leaving examinations; UCAS application form; examples of recent written work submitted to the College to which they are applying; and performance at interview, if invited to attend.

When using the specimen Specimen papers and past papers below, please for the Natural Sciences Admission Assessment are available below. Before you attempt the papers, make sure you read the related specimen papers information and guidance.

Please note that the following changes to the Natural Sciences admissions assessment Admissions Assessment (NSAA) were introduced in 2020:

Natural Sciences Admission Assessment NSAA



Appendix: Calendars and time management

April						
S	M	T	W	T	F	S
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30				

May						
S	M	T	W	T	F	S
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	

June						
S	M	T	W	T	F	S
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30						

July						
S	M	T	W	T	F	S
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	31			

August						
S	M	T	W	T	F	S
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	31

September						
S	M	T	W	T	F	S
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30					

October						
S	M	T	W	T	F	S
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31		

November						
S	M	T	W	T	F	S
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30

December						
S	M	T	W	T	F	S
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

January						
S	M	T	W	T	F	S
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	

February						
S	M	T	W	T	F	S
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	

March						
S	M	T	W	T	F	S
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	31					

April						
S	M	T	W	T	F	S
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30			

May						
S	M	T	W	T	F	S
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	31

June						
S	M	T	W	T	F	S
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30					



CAMBRIDGE

International Education

Cambridge Final Exam Timetable November 2024

Administrative zone 5

Cambridge IGCSE™

Cambridge O Level

Cambridge International AS & A Level

Cambridge Final Exam Timetable November 2024

Syllabus view (A-Z)



CAMBRIDGE
International Education

Cambridge International AS Level

Syllabus/Component	Code	Duration	Date	Session
A				
Accounting (Multiple Choice)	9706/12	1h	Tuesday 12 November 2024	PM
Accounting	9706/22	1h 45m	Thursday 17 October 2024	PM
Afrikaans Language	8679/02	1h 45m	Tuesday 08 October 2024	AM
Afrikaans Language	8679/03	1h 30m	Tuesday 01 October 2024	AM
B				
Biblical Studies	9484/13	1h 30m	Thursday 24 October 2024	EV
Biology (Multiple Choice)	9700/13	1h 15m	Tuesday 12 November 2024	AM
Biology	9700/23	1h 15m	Tuesday 22 October 2024	AM
Biology (Practical - Advanced)	9700/35	2h	Tuesday 08 October 2024	AM
Biology (Practical - Advanced)	9700/36	2h	Tuesday 05 November 2024	AM
Business	9609/12	1h 15m	Monday 07 October 2024	PM
Business	9609/22	1h 30m	Thursday 10 October 2024	PM
C				
Chemistry (Multiple Choice)	9701/13	1h 15m	Thursday 14 November 2024	AM
Chemistry	9701/23	1h 15m	Friday 18 October 2024	AM
Chemistry (Practical - Advanced)	9701/35	2h	Tuesday 01 October 2024	AM
Chemistry (Practical - Advanced)	9701/36	2h	Tuesday 29 October 2024	AM
D				
Biblical Studies	9484/43	1h 30m	Monday 11 November 2024	EV
Biology	9700/43	2h	Friday 25 October 2024	AM
Biology	9700/53	1h 15m	Tuesday 22 October 2024	AM
E				
Chemistry	9701/43	2h	Monday 04 November 2024	AM
Chemistry	9701/53	1h 15m	Friday 18 October 2024	AM

Syllabus/Component	Code	Duration	Date	Session
G				
Geography (Core)	9696/13	1h 30m	Monday 21 October 2024	AM
Geography (Core)	9696/23	1h 30m	Friday 25 October 2024	AM
German Language	8683/23	1h 45m	Monday 28 October 2024	AM
German Language	8683/33	1h 30m	Thursday 03 October 2024	AM
Global Perspectives & Research	9239/12	1h 30m	Tuesday 01 October 2024	PM
H				
History	9489/12	1h 15m	Thursday 17 October 2024	PM
History	9489/22	1h 45m	Monday 21 October 2024	PM
I				
Information Technology	9626/13	1h 45m	Friday 11 October 2024	AM
L				
Language & Literature in English	8695/13	2h	Thursday 31 October 2024	AM
Language & Literature in English	8695/23	2h	Monday 14 October 2024	AM
Law	9084/12	1h 30m	Monday 30 September 2024	PM
Law	9084/22	1h 30m	Wednesday 02 October 2024	PM
Literature in English	9695/13	2h	Monday 14 October 2024	AM
Literature in English	9695/23	2h	Friday 25 October 2024	AM
M				

M				
Marine Science	9693/33	1h 45m	Tuesday 29 October 2024	AM
Marine Science	9693/43	1h 45m	Friday 01 November 2024	AM



Planning your days V1.0

Period	Time	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
	5:00 am							
	5:30 am							
	6:00 am							
	6:30 am							
	7:00 am							
Regstn	7:25 am							
1	7:50 am							
2	8:40 am							
3	9:30 am							
4	10:20 am							
5	11:00 am							
Lunch	11:50 pm							
6	1:10 pm							
7	2:00pm							
8	2:50 pm							
9	3:40 pm							
	4:20 pm							
	5:00 pm							
	5:30 pm							
	6:00 pm							
	6:30 pm							
	7:00 pm							
	7:30 pm							
	8:00 pm							
	8:30 pm							
	9:00 pm							
	9:30 pm							
	10:00 pm							
	10:30 pm							



Planning your days – v2.0

Period	Time	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
	5:00 am							
	5:30 am							
	6:00 am							
	6:30 am							
	7:00 am							
Regstn	7:25 am							
1	7:50 am							
2	8:40 am							
3	9:30 am							
4	10:20 am							
5	11:00 am							
Lunch	11:50 pm							
6	1:10 pm							
7	2:00pm							
8	2:50 pm							
9	3:40 pm							
	4:20 pm							
	5:00 pm							
	5:30 pm							
	6:00 pm							
	6:30 pm							
	7:00 pm							
	7:30 pm							
	8:00 pm							
	8:30 pm							
	9:00 pm							
	9:30 pm							
	10:00 pm							
	10:30 pm							



Planning your days – v3.0

Period	Time	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
	5:00 am							
	5:30 am							
	6:00 am							
	6:30 am							
	7:00 am							
Regstn	7:25 am							
1	7:50 am							
2	8:40 am							
3	9:30 am							
4	10:20 am							
5	11:00 am							
Lunch	11:50 pm							
6	1:10 pm							
7	2:00pm							
8	2:50 pm							
9	3:40 pm							
	4:20 pm							
	5:00 pm							
	5:30 pm							
	6:00 pm							
	6:30 pm							
	7:00 pm							
	7:30 pm							
	8:00 pm							
	8:30 pm							
	9:00 pm							
	9:30 pm							
	10:00 pm							
	10:30 pm							



Planning your days – v4.0

Period	Time	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
	5:00 am							
	5:30 am							
	6:00 am							
	6:30 am							
	7:00 am							
Regstn	7:25 am							
1	7:50 am							
2	8:40 am							
3	9:30 am							
4	10:20 am							
5	11:00 am							
Lunch	11:50 pm							
6	1:10 pm							
7	2:00pm							
8	2:50 pm							
9	3:40 pm							
	4:20 pm							
	5:00 pm							
	5:30 pm							
	6:00 pm							
	6:30 pm							
	7:00 pm							
	7:30 pm							
	8:00 pm							
	8:30 pm							
	9:00 pm							
	9:30 pm							
	10:00 pm							
	10:30 pm							



Appendix: Performance in standardised tests of English language proficiency such as IELTS

If you are a learner where English is not your first language than you are likely to need to sit a standardised tests of English language proficiency such as IELTS.

A good and effective command of English will help drive success in these kinds of exams. For a variety of reading lists and activities to help improve your English language skills in a non-specific but still important way, especially for top universities, go here: <https://www.smashingscience.org/expanding-your-mind>

Regardless of which English language speaking university you eventually attend⁵², and even if it not English is not a national language⁵³, scoring higher in your English language standardised test has deep and powerful value to your success at university. It will not only improve the easier-to-measure things like academic success, but also have a potentially more valuable impact on your ability to interact positively and productively with other students, academics and professionals while you are at an English language university.

For specific strategies for the various kinds of standardised test, talking to your English teacher should be your starting point. As with any kind of skilful action, like making a great UCAS application, you should **start preparing early**, and map out when the deadlines are going to land in your weeks, months and years so you can properly plan around them and for them.

One thing that sometimes surprises students is how inflexible some universities are about the English language requirements. But your time at university ought to be a transformative experience, and in a good way; an eye opening and amazing time of growth. This change becomes less and less likely when the language barriers get higher and higher.

Appendix: Individual contextual factors

This includes this form, which allows you to describe and explain how the pandemic impacted your education:

Additional Applicant Information Form (AAIF) – 2024 entry⁵⁴

It looks like a fairly straightforward form.

Appendix: Contextual data

"The University of Cambridge [is committed](#) to ensuring that we offer admission to students of the highest academic potential, irrespective of social, racial, religious and financial considerations."

There are only a small number of points that a student will have an input for this part of the Cambridge selection process. In the "[My Cambridge Application](#)" you can include if "you have been eligible for Free School Meals", one way that economic disadvantage is measured and tracked in the UK, and if "they have spent time in local authority care"⁵⁵, a measure of educational disadvantage.

"However, academic achievement remains central to all admissions decisions - 'flagged' applicants won't necessarily be invited to attend an interview, be made an offer or be made a conditional offer at lower grades."

It is possible therefore that some of the small number of offers and acceptances with non-A*A*A* profiles (see *A Level grade profiles for 2022*, at the start of this book) may come from a cohort identified here. **If you have succeeded despite these challenges and your grades are not quite there, then this program is designed to give you credit for overcoming the kinds of challenges that most Oxbridge applicants have not, and you ought to apply.**

⁵² <https://www.tandfonline.com/doi/full/10.1080/13803611.2024.2314533#abstract>

⁵³ <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10404714/>

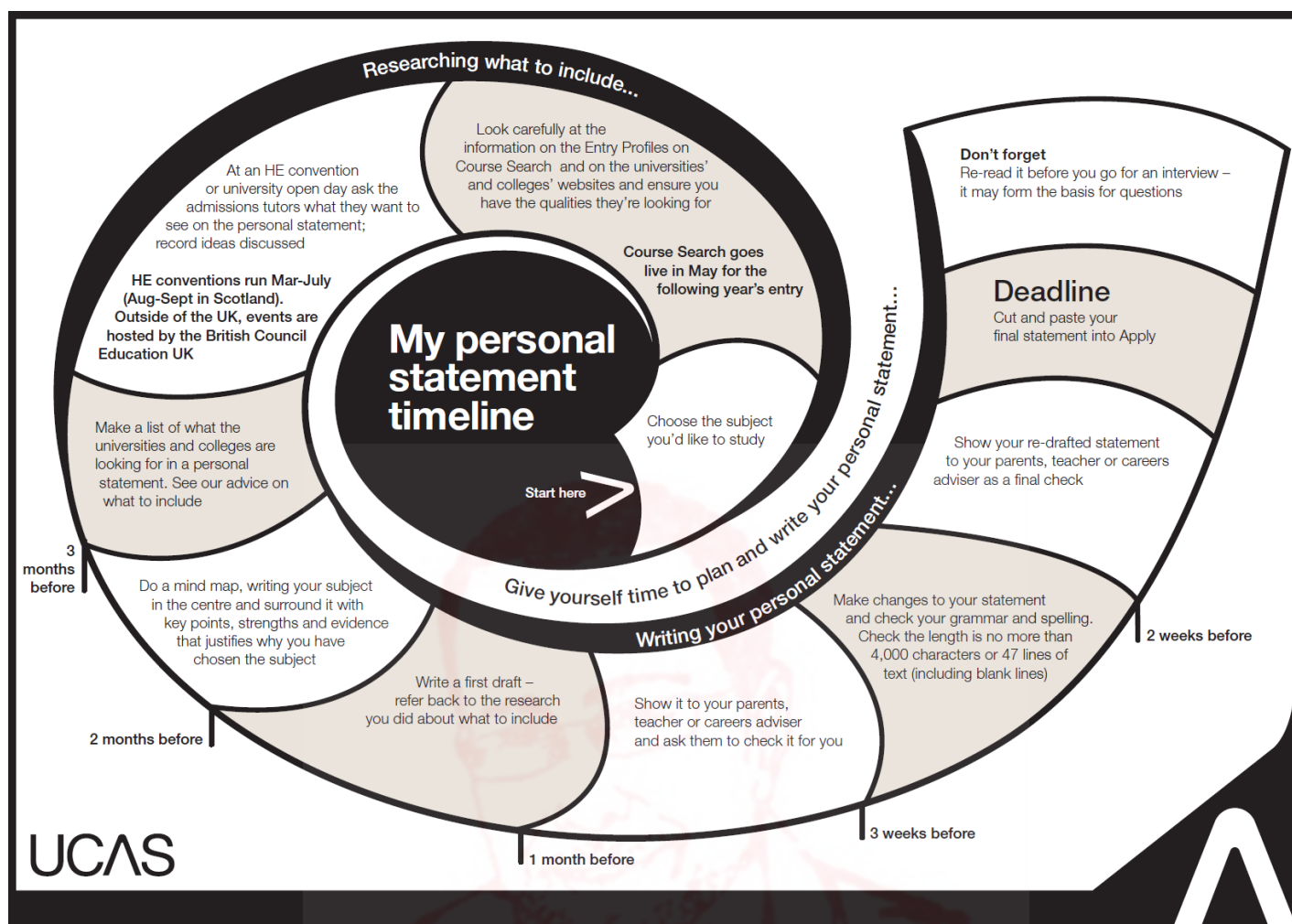
⁵⁴ https://www.undergraduate.study.cam.ac.uk/files/aaif_guide.pdf

⁵⁵ <https://www.undergraduate.study.cam.ac.uk/apply/after/contextual-data>



Appendix: Personal Statement advice and information

From UCAS a possible timeline for a good top 50 university application, but especially helpful with the writing aspect of it, which is the least important part:



The best personal statements are the not result of great writing, but magnificent living.

For a good Oxbridge application, the work needs to be started much, much earlier than your AS year of study.

It is essentially a highlight list of interesting, difficult to achieve and important things you have done outside of the classroom that explains how passionate, curious and hardworking you are about the subject you are applying for.

Some experiences, for instance 3 years of being the most active member of an evidently successful and obviously active extracurricular Chemistry Society are difficult to achieve, and normally only the most organised and goal oriented Oxbridge applicants. But a much, much larger proportion of those who are offered a place will be offering those kinds of things.

It can be helpful to think about it as blocks of time. You need to start thinking about whichever subject you are thinking of applying to study at university normally when you chose your GCSEs, and you should have good idea of what you could do when you chose your A Levels in your final year of GCSEs.

Organising your years to create the life experiences that the best personal statements contain

You will begin gaining important life experiences years before your UCAS application year, but a magnificent amount of growth will come through your failures, some of which take months or even years to appreciate. For instance, how do you learn when is too late to apply for a summer program? If it is something really awe-inspiring, rare and worthwhile, learning that the application deadline was last week will give you the most long lasting and powerful lesson in the value of proactive time management. If this happens in a GCSE year it can help you with your all-important summer going into your A2 year.

Cambridge has suggestions of things you could do that they would value, though they don't explain how they would rank two otherwise identical applications with two different kinds of experiences here:

https://www.undergraduate.study.cam.ac.uk/files/publications/super-curricular_suggestions.pdf

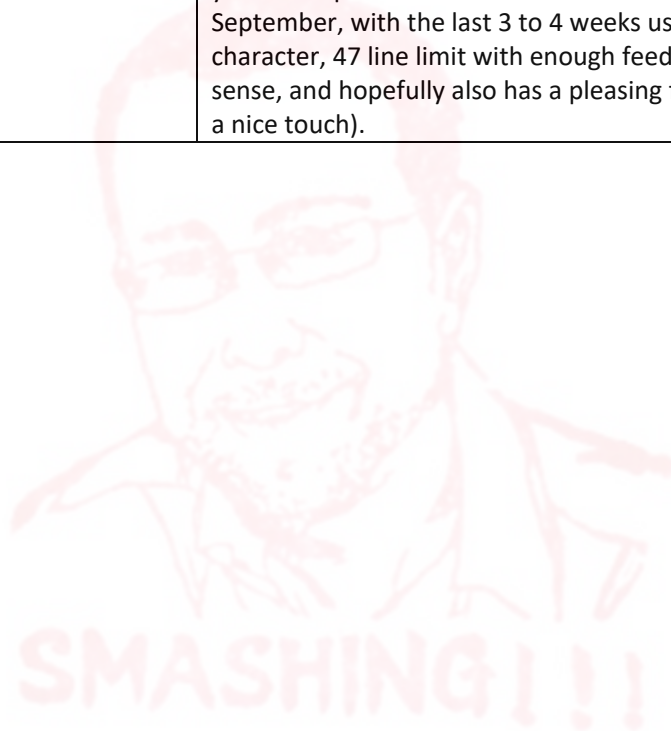
A general rule that can help is if the activity is easy to do, fun and/or impossible to verify, like watching a video, then it is less likely to be helpful in a personal statement. Some summer camps run by private companies for instance, but even ones that are held in the University buildings, and especially the ones where the main way of selecting their participants is centred around paying a usually large fee, are less useful, perhaps even useless. Chasing squirrels in a park or watching a nice movie would both be considerably cheaper activities, and probably deliver as much, if not more, positive value to your Oxbridge application than these kinds of expensive, challenge-free holiday-like experiences.

The kinds of activities that are more valuable, when done well, will have overlapping and reinforcing effects on your learning. Talking to your teachers about their subjects, and the harder parts of the syllabus, for instance, won't only help improve your eventual UCAS reference. And learning about academic competitions and working towards their deadlines to prepare for their tests, will also help you with your academic exams, especially the value and power of starting early to deliver your strongest performance. And learning about working to deliver a positive, productive and successful performance within predictable but sometimes challenging deadlines is the single best thing the best applicants will get out of their Oxbridge application, regardless if they get an offer or not.

Block of time	Main events	What you can do
The year before GCSEs start	Decide optional GCSE subjects What are you best at	Start learning about careers (how much they pay, how long do you need to train, what are the typical working hours, are you interested in the work?)
First year of GCSE	Start a more serious qualification. Learn about the power of past exam questions in delivering academic success.	Learn about careers – Are you still interested in that kind of work? What degrees help achieve that career? Start learning about extracurricular activities , participate in school, learn about what can be done outside of school. Find out how they work well, and when they don't work, or are not productive (zombie societies and clubs that exist but achieve nothing). How could you show later on that you made an active and successful contribution? Learn about deadlines for academic competitions , some have junior or intermediate versions that are suitable for GCSE students
Summer going into final GCSE year	Learning about summer activities	Discover summer activities - what can be done, and when you need to apply. Discover how hard it is to do worthwhile things in the summer that are difficult to achieve (need very early applications, few opportunities, difficult to organise into your life). Think about how different these hard to get selected for and hard to organise activities are from the kinds of activities where the only qualification is paying the usually large fee.
Second year of GCSEs	Learn about effective time management to deliver success in your: <ul style="list-style-type: none"> • months • weeks • days Start reading one news article a week in your favourite subjects	Participate in academic competitions , learn how to organise your time to compete as well as succeed in all of your GCSE subjects Learn about the most impressive academic clubs and societies in your school, what can you do to have a senior position next year. If the perfect society for you doesn't exist, create it in this year. Think about which teachers could be your UCAS reference and start talking to them about your subject inside and outside of lesson time, ideally about harder parts of the course and occasionally about new scientific advances. Often teachers are busy, so take the care to ask them if they are busy, or if they can talk about something you find interesting at that moment.
Summer going into AS year	Do something useful, interesting and valuable with your summer	Use your experiences trying to organise something interesting and worthwhile in your previous summer to apply better for this summer: <ol style="list-style-type: none"> 1. be early (start in September) 2. learn about realistic opportunities 3. know requirements (e.g. references, essays etc) 4. know the deadlines



Block of time	Main events	What you can do
		<p>5. learn about opportunities only available to students a year older (so you can get a head start this next year)</p> <p>This could be a good sentence or two in your personal statement, but hopefully the experiences closer to the application would be too valuable to give this experience the space. A really great personal statement will leave out many excellent achievements.</p>
First year of AS	<p>Academic competitions</p> <p>Extracurricular societies, clubs and activities</p> <p>Read academic books recommended by Oxbridge</p>	<p>These experiences, especially building on previous years will deliver a complete and strong paragraph in your personal statement.</p> <p>Read 3 to 6 books about your subject that are (not textbooks) about recent advances that you enjoy (and take notes on them): https://www.ox.ac.uk/admissions/undergraduate/courses/suggested-subject-resources This can deliver a strong sentence, or add to another paragraph in your personal statement.</p>
Summer going into AS year	Most important summer for activities and accomplishments	Participate and complete something amazing, fascinating and really hard to achieve this summer. This will be a solid paragraph in your personal statement.
A2 year	Apply for UCAS	Nothing much for an Oxbridge personal statement can be done in this year. Your personal statement should be essentially finished in early September, with the last 3 to 4 weeks used to fit within the 4000 character, 47 line limit with enough feedback so that it still makes sense, and hopefully also has a pleasing flow to it (less important, but a nice touch).



Appendix: Oxbridge Reading Lists for Chemistry and Biology

For a digital version of this scan this QR code for clickable links (in e.g. MS Word app):

Chemistry in the news – Where to learn about recent important events.

Try to read **3 interesting** and **2 useful** articles every week of A2 (or 1 of each type every week at AS):

UK – Royal Society of Chemistry Magazine (recommended by Oxford Uni):

<https://www.chemistryworld.com/news>

US – American Chemical Society Magazine:

<https://www.acs.org/education/resources/highschool/chemmatters.html>

Science news websites

International News – Associated Press (less focused on the science of “chemistry”): <https://apnews.com/hub/chemistry>

<https://www.sciencenews.org/topic/chemistry>

Requires subscription (possibly worth it in A2):

<https://www.newscientist.com/article-topic/chemistry/>

Especially good if also interested in business and finance: <https://www.economist.com/science-and-technology>

Oxford research in chemistry (recommended by Oxford Uni):

- [Turning orange into grapefruit](#)
- [Fuel cells inspired by nature video](#)
- [Chemistry in the garden video](#)

Science Podcasts

NPR: Short Wave - Short (10min) episodes on a single science news topic. Very good.

NYT: Hard Fork – Weekly technology with a focus on Silicon Valley news. Outstanding.

Economist: Babbage – Weekly science podcast (subscription may be necessary) focusing on a single topic. 40minutes. Excellent

Universe Today: Fraser Crain – A focus on astronomy, cosmology, and space news. Reliably Excellent, often outstanding.

BBC: In our Time with Melvyn Bragg – Sometimes covers science, always outstanding.

New Scientist: Podcast – Science news. It can be good.

Freakonomics M.D. – Investigating the intersection of economics and medicine. Excellent.

BBC: The Infinities Monkey Cage – Panel talk show on big science topics. Often very good.

Stephen Fry’s Great Leap Years – History of science and technology. Outstanding.

BBC Discovery – “An in-depth look at the most significant ideas, discoveries and trends in science”. Often good.

BBC: History Extra Podcast – Sometimes covers the history of science or scientists, always excellent, often outstanding.

Nature Podcast – Outstanding science packaged into a relentlessly mediocre podcast.

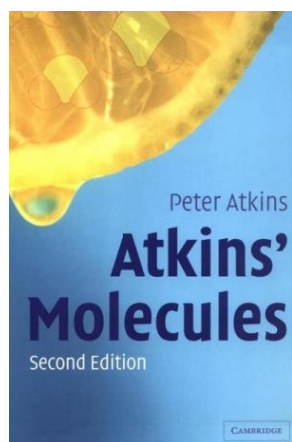


General and Popular Chemistry Books

These books are all from this site:

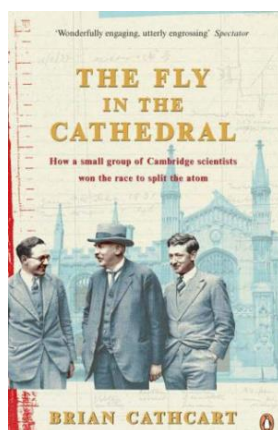
<https://www.univ.ox.ac.uk/applying-to-univ/reading-bank/?category=maths-physical-life-sciences&subcategory=chemistry>

If you click on each you can get a review by the Oxford student (their degree subject is in brackets)



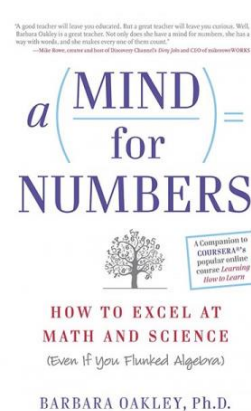
[Atkins' Molecules](#)

By Peter Atkins



[The Fly in the Cathedral](#)

By Brian Cathcart



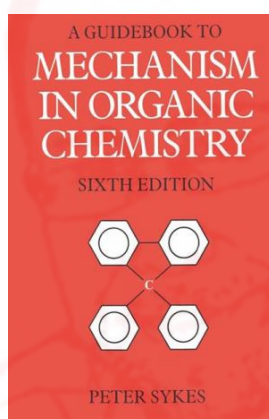
[A Mind for Numbers](#)

By Barbara Oakley



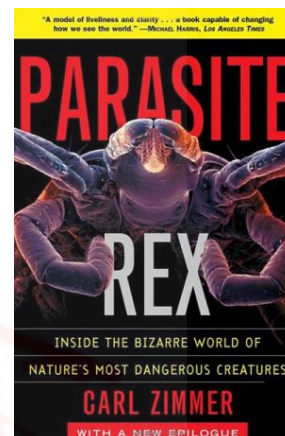
[Chemistry Review](#)

By Hodder Education



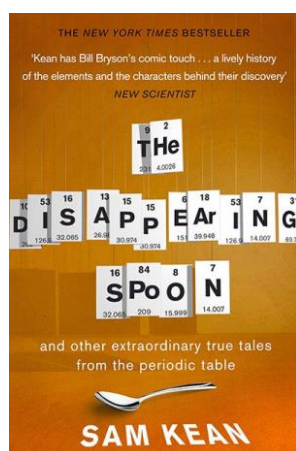
[Guidebook to Mechanism in Organic Chemistry](#)

By Peter Sykes



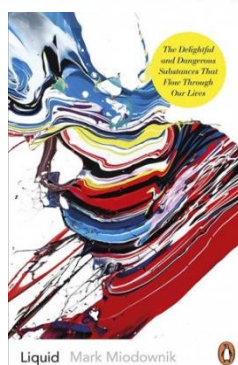
[Parasite Rex](#)

By Carl Zimmer



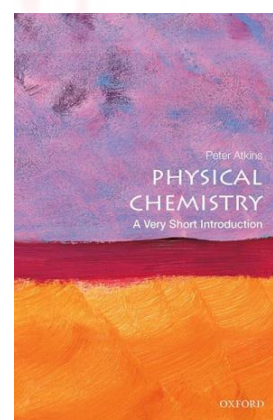
[The Disappearing Spoon](#)

By Sam Kean



[Liquid](#)

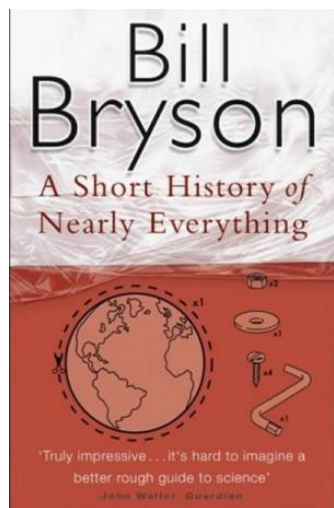
By Mark Miodownik



[Physical Chemistry: A Very Short Introduction](#)

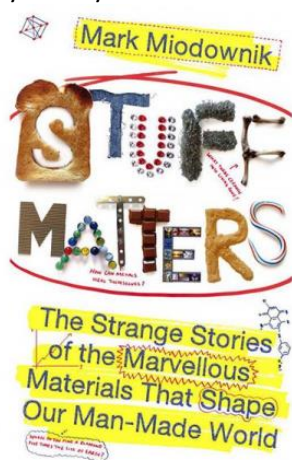
By Peter Atkins





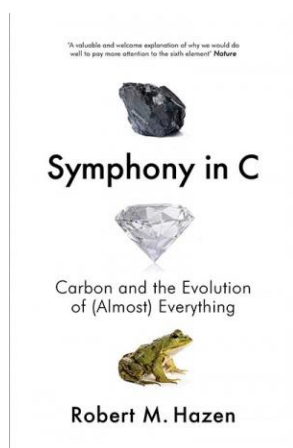
[A Short History of Nearly Everything](#)

By Bill Bryson



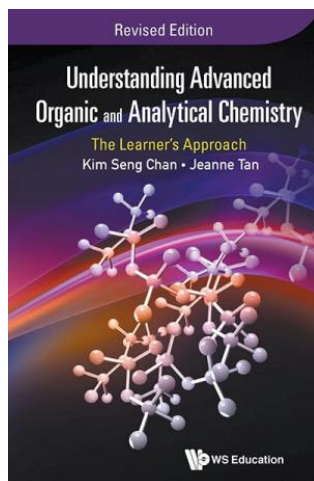
[Stuff Matters](#)

By Mark Miodownik



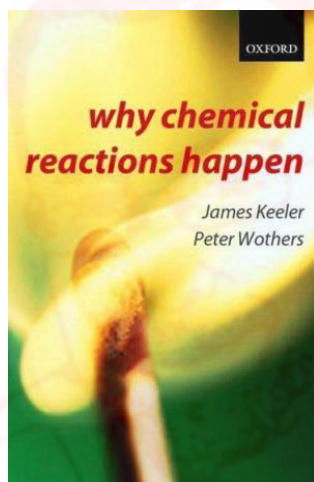
[Symphony in C: Carbon and the Evolution of \(Almost\) Everything](#)

By Robert M Hazen



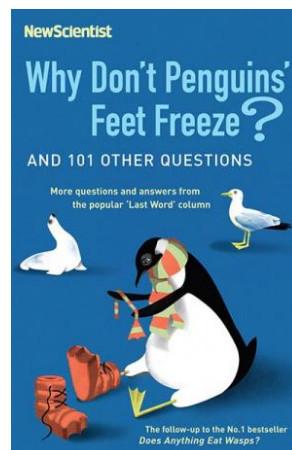
[Understanding Advanced Organic and Analytic Chemistry](#)

By Kim Seng Chan and Jeanne Tan



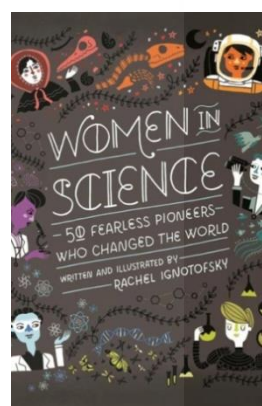
[Why Chemical Reactions Happen](#)

By James Keeler and Peter Wothers



[Why Don't Penguins' Feet Freeze?](#)

By New Scientist



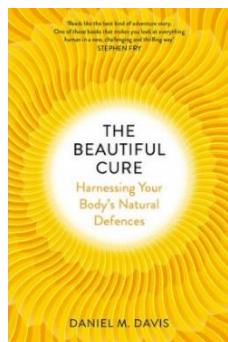
[Women in Science](#)

By Rachel Ignotofsky

General and Popular Biology Books

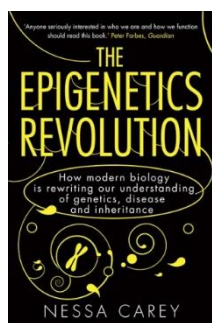
These books are all from this site: <https://www.univ.ox.ac.uk/applying-to-univ/reading-bank/?category=maths-physical-life-sciences&subcategory=biology>

If you click on each you can get a review by the Oxford student (their degree subject is in brackets)



[The Beautiful Cure](#)

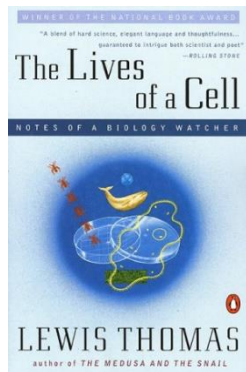
By Daniel M Davis



[The Epigenetics Revolution](#)

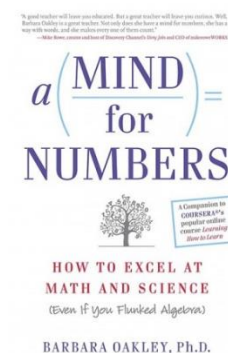
By Nessa Carey

Reviews by Katie H



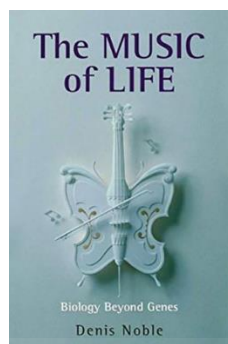
[The Lives of a Cell](#)

By Lewis Thomas



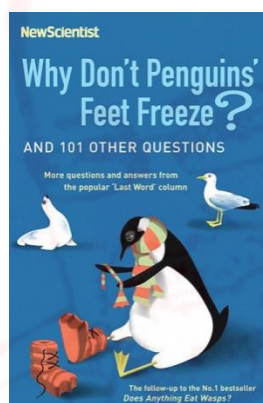
[A Mind for Numbers](#)

By Barbara Oakley



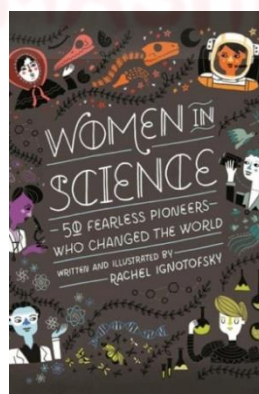
[The Music of Life - Biology Beyond Genes](#)

By Denis Noble



[Why Don't Penguins' Feet Freeze?](#)

By New Scientist



[Women in Science](#)

By Rachel Ignotofsky



Chemistry Textbooks

These books can be of help to further pursue ideas you find fascinating at A2, but you should probably try these online textbooks:

For A level chemistry: <https://www.chemguide.co.uk/>

For some A level and mainly undergraduate chemistry (also has online textbooks about other subjects):
<https://chem.libretexts.org/>

For the Wikipedia Portal for everything chemistry: <https://en.wikipedia.org/wiki/Portal:Chemistry>

From Oxford University (accessed 29th Aug 2023):

<https://www.ox.ac.uk/admissions/undergraduate/courses/suggested-subject-resources>

Introductory reading for Chemistry.

*Physical Chemistry, P W Atkins, Oxford University Press (8th edn.) 2006, [7th edn. 2001]

* Inorganic Chemistry, Shriver and Atkins, Oxford University Press (4th edn) 2006, (previous edn., 1999]

Chemistry of the Elements, Greenwood & Earnshaw, Pergamon (2nd edn.), 1997 [1st edn. 1985]

Foundations of Organic Chemistry, Hornby & Peach, Oxford Chemistry Primer, OUP, 1996

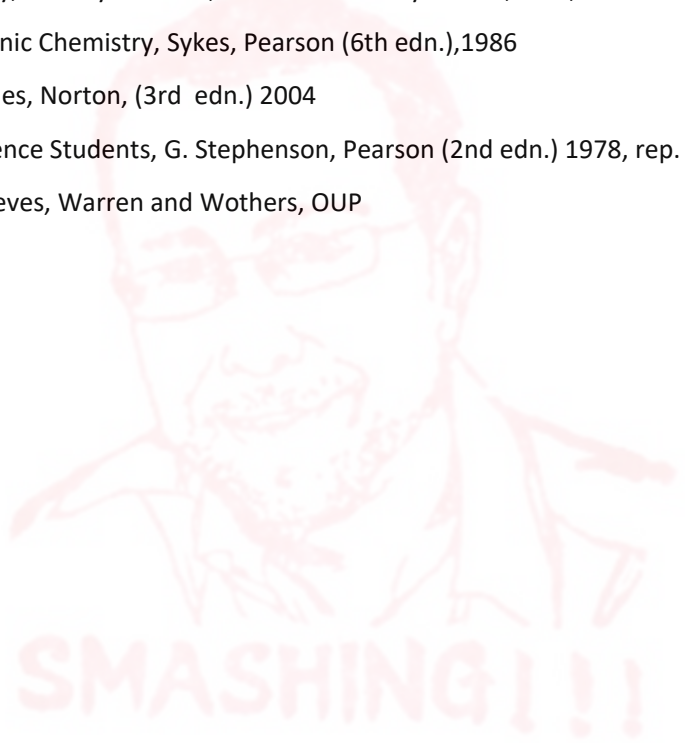
* A Guide to Mechanism in Organic Chemistry, Sykes, Pearson (6th edn.), 1986

Organic Chemistry, Maitland, Jones, Norton, (3rd edn.) 2004

* Mathematical Methods for Science Students, G. Stephenson, Pearson (2nd edn.) 1978, rep. 1984

Organic Chemistry, Clayden, Greeves, Warren and Wothers, OUP

*especially useful



Appendix: Degree subjects which require interviews

If done before you submit your UCAS application this worksheet can help you learn which universities and courses interview prospective students and what that means.

Like any exam or assessment, to excel you need to understand what is being measured or investigated in order to deliver your best performance. Filling out this completed form not only will help you prepare better, you will also feel more prepared, so less stressed. But this work you do learning about this process also can help others who are helping you succeed, like parents, guardians and teachers be better informed.

For the courses that you intend to study, complete this table for the degrees and universities you are most interested in to find out if they interview. Normally effective would be a Google search with: "[university name] interview undergraduate".

For completed versions of these tables accurate as of November 2023 see the same table filled in for some universities further along here.

University	Course name	UCAS code	Department undergraduate website	Do they interview?
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				

Now read through each webpage above for those that interview, then close your web browser and write out the key details from memory in the space below. Then go back to the website and fill in, with a different colour, the information you missed. A completed version for some course as of November 2023 follows on

University & course	Online?	Key interview details

University & course	Online?	Key interview details

Learning more about your chosen course and the best universities that offer it
Using Admission report to better understand your potential university choices

<https://www.admissionreport.com/schools>

University & course	Admissions report information		UCAS information	
	Offer rate	Year data comes from	Required A Level Grades	GCSE requirements
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				

University	Course name	UCAS code	Department undergraduate website	Do they interview?
Birmingham	Most subjects		https://www.birmingham.ac.uk/students/ug-admissions/solution?answered=4171&nodeid=4171	No
Bristol	Chemistry		https://www.bristol.ac.uk/study/undergraduate/after-you-apply/interviews/chemistry/	Yes, & all non-standard applications
Bristol	Biology		https://www.bristol.ac.uk/study/undergraduate/after-you-apply/interviews/	No
Cambridge	Natural Science	BCF0	https://www.undergraduate.study.cam.ac.uk/courses/natural-sciences	Yes
Durham	All courses (except Primary education)		https://www.durham.ac.uk/study/undergraduate/how-to-apply/what-happens-to-your-application/interviews-and-selection-days/	No
Imperial College	Chemistry	F100	https://www.imperial.ac.uk/study/courses/undergraduate/chemistry-bsc/	Yes
Imperial College	Biochemistry	C700	https://www.imperial.ac.uk/study/courses/undergraduate/biochemistry-bsc/ - "Generally, the department does not hold interviews."	No
Imperial College	Biology	C100	https://www.imperial.ac.uk/study/courses/undergraduate/biological-sciences/ - "Generally, the department does not hold interviews."	No
Imperial College	Material science & engineering, MEng	JFM2	https://www.imperial.ac.uk/study/courses/undergraduate/materials-science-engineering-meng/	Yes
Imperial College	Chemical engineering, MEng	H801	https://www.imperial.ac.uk/study/courses/undergraduate/chemical-engineering/	Maybe
Manchester	Biology	C100	https://www.manchester.ac.uk/study/undergraduate/courses/2024/00524/bsc-biology/application-and-selection/#course-profile "How your application is considered Applications are considered on the basis of the UCAS form. Some candidates may be interviewed online or by telephone, or asked to complete an alternative admissions statement."	Probably not
Oxford	Chemistry, MChem	F100	https://www.chem.ox.ac.uk/admissions	Yes
UCL	Chemistry	F100	https://www.ucl.ac.uk/chemistry/study-here/undergraduate	No
UCL	Pharmacy		https://www.ucl.ac.uk/prospective-students/undergraduate/how-apply/how-we-assess-your-application	Yes
Warrick	Most subjects		https://warwick.ac.uk/study/international/admissions/help/do_all_applications_include_an_interview/	No

University & course	Online?	Key interview details
IC Chem, F100	Probably, (can't say, previously always was for international students)	<p>Time: Morning and Afternoon (to cater to different time zones)</p> <p>Date: Ongoing it seems, but given offers only made after all interviews are complete at the end of March, has to be before then.</p> <p>Purpose: Assess motivation for studying chemistry and potential for the future. Also how they think and how they reason through a problem</p> <p>Format: Individual interview with an academic</p> <p>Additional information: Pre-recorded talk by the admissions department</p> <p>Add info: Online Q and A sessions</p> <p>Add info: Virtual tour of department: https://virtual-tour.imperial.ac.uk/explore/chemistry/wider-department-2?study_level=undergraduate&subject_area=chemistry</p> <p>Content assessed: Personal statement initially, then could be about "unfamiliar topics"</p> <p>Offers: only made after all interviews are complete, by email, end of March</p>
IC Material science and engineering, JFM2	Probably, (can't say, previously always was for international students)	<p>Time: 10:30 to 15:30</p> <p>Date: Between November and March</p> <p>Format: Happens in a single whole "Applicant Day", which includes talks by Director of Undergraduate Studies then the Admissions Tutor</p> <p>Content 1 to 1 interview: with a lecturer for 30minute. "We aim for the interview to be more of a conversation.", so perhaps about the personal statement?</p> <p>Content group task: a 45minute engineering based problem solving challenge working in a team. [Not on the website] but previous years students have given a topic, like "What is the material of the future?" 24hours in advance and then required to deliver a 90second introduction to a material you have researched, with the group time also used to explore your research and understanding of your chosen material].</p> <p>Content Q&A: With current student ambassadors for 60minutes.</p> <p>Most international students, including Chinese nationals, need to get an ATAS certificate to get student visa</p>
UCL Chem, F100		<p>Not on this list (therefore does not use interviews for this course): https://www.ucl.ac.uk/prospective-students/undergraduate/how-apply/how-we-assess-your-application</p> <p>Use "gathered field" approach to assess UCAS applications: "All applications submitted by 6pm UK time on 25 January 2023 are given equal consideration."</p> <p>They then say:</p> <p>"Gathered fields - A gathered field allows us to assess all applications in the same fair and consistent manner, whether they are received in October or January (by the UCAS deadline). This means we will need to wait until we have enough comparable applications to make a final decision."</p> <p>What is logically possible from these statement:</p> <ol style="list-style-type: none"> 1. They clearly want it known that they believe equal consideration is given to any applicant delivered at any time before the UCAS deadline. 2. The final decision will be delivered after they have "enough comparable applications", which can be before the UCAS deadline.
IC, Chem Eng, MEng H801	Probably	<p>This was accessed on 31st October 2023:</p> <p>"Interview days</p> <p>The Department plans to hold interview days as part of the selection process. Check back soon for more information."</p>
Oxford	Probably, did in 2023, but may have changed since	<p>[Like Cambridge,] use interviews to see if students are suited to the small class tutorial structure of their undergraduate course [no other university uses it].</p> <p>Shortlisting: At least 2 interviews at their first-assigned college (could also be interviewed by their second-assigned college, or other colleges).</p> <p>Best 10,000 applicants are invited for interview for 3,300 places (total 22,000 applicants; most do not get an interview)</p> <ul style="list-style-type: none"> • Middle November to early December interview notices emailed • Early to mid-December interviews carried out • Candidates interviewed by a different college finish in mid-December, soon after initial interviews (none of Cambridge's perplexing "Winter Pool" business)

		<p>Shortlisting: At least 2 interviews at their first-assigned college (could also be interviewed by their second-assigned college, or other colleges)</p> <p>Content of interview</p> <ul style="list-style-type: none"> • First, about personal statement or why you chose that course • Subject specific, including about a text, graph, object [e.g. image] • Can also include content about your current A Levels • Can also include what you have read around the subject and your interests beyond syllabus <p>If you don't know the answer:</p> <ul style="list-style-type: none"> • Exploring your thought process [by speaking your thoughts] will interest them [but they may not only be interested in ways you succeeded at interview] • Apply logic and reason to the question • Tell them if you have not covered it yet, but remain enthusiastic about wanting to find the answer [don't use that stamen "I've not covered that yet" as the solution, or the reason you don't have to be interested in the idea; if it is not from A Level, then they may be assessing your general interest in the subject] • Evidence of your ability to think about an idea differently could be what the examiner is trying to uncover. So, eagerness, intellectual flexibility and a capacity to bear being stretched while solving a problem allows them to assess your potential • Finally "just be yourself", advice that will be interpreted wildly differently by different demographics. If everyone in your life has a competitive, professional highly educated background, than this could mean "display your best self, and avoid highlighting your faults". It highlights the profound tension that exists in everything that they write about this selection process, they are likely aiming for it to come across as a merit based, fair, rigidly logical process that is highly successful at selecting the very best students, regardless of their background. Saying you should "just be yourself" is like saying "be honest" which is an ideal that we all should aspire towards, but it is a striking thread they are pulling on. <p>https://www.ox.ac.uk/admissions/undergraduate/applying-to-oxford/guide/interviews</p>
Cambridge	Probably, did in 2023, but may have changed since	<ul style="list-style-type: none"> • Invitations for interview in November. • Interviews in December. • Potential additional interview in early January (Winter Pool). <p>All students with an offer have an interview. 35-50minutes total interview time Most applicants offered an interview, number of interviews (usually 1 or 2) not connected with chances of offer. Normally get at least one subject specific interview, essentially an exam in spoken form. Some questions you are not expected to know the answer to, but to use the information provided to work it out in the moment.</p> <p>Content assessed:</p> <ul style="list-style-type: none"> • Personal statement • Using existing knowledge to solve unknown problems • News in your subject <p>General academic interview content assessed:</p> <ul style="list-style-type: none"> • Personal statement • Why Cambridge, why [your subject] • Other academic interests or work • Your plans after your degree <p>https://www.undergraduate.study.cam.ac.uk/apply/after/cambridge-interviews</p>

Appendix: Science subjects that require an entrance exam

Imperial College⁵⁶ Science Subjects Entrance Exams

Unlike Oxford or Cambridge, there is an opportunity to take the test at the start of January

Test format

The ESAT is a computer-based assessment. It is made up of individual multiple-choice modules lasting 40 minutes each. You will sit these back-to-back on the day of the test.

Mathematics 1 is compulsory for all candidates.

The remaining modules will depend on the Imperial course you are applying to.

In most cases, you will complete two additional multiple-choice modules, making the test 120 minutes in total. For the Dyson School of Design Engineering you will only be required to complete one additional module, which is Mathematics 2. Details of which modules to select for each Imperial department can be found in the table below:

Department	Test	Module 1	Module 2	Module 3
Aeronautics	ESAT	Mathematics 1	Physics	Mathematics 2
Chemical Engineering	ESAT	Mathematics 1	Chemistry	Mathematics 2
Civil and Environmental Engineering	ESAT	Mathematics 1	Physics	Mathematics 2
Dyson School of Design Engineering	ESAT	Mathematics 1	Mathematics 2	N/A
Electrical and Electronic Engineering	ESAT	Mathematics 1	Physics	Mathematics 2
Mechanical Engineering	ESAT	Mathematics 1	Physics	Mathematics 2
Physics	ESAT	Mathematics 1	Physics	Mathematics 2

There is no pass or fail for ESAT. You should aim to do the best you can.

Your final scores are based on the number of correct answers you give. You do not lose marks for wrong answers, so it's worth attempting all questions.

Test dates

You must register and book a time slot in advance of the test taking place.

You can choose whether you sit the test in October or January.

- **Test sitting 1:** 15 and 16 October 2024; or
- **Test sitting 2:** 7 and 8 January 2025.

We will only accept the results from your first test sitting per admissions cycle (even if you sit the test twice), so you should aim to do the best you can.

There is no advantage to sitting the test in the first or second sitting. However, we strongly encourage you to register for test sitting 1, where possible, to have access to the widest choice of time slots in your chosen location.

University of Cambridge⁵⁷ Science Subjects Entrance Exams

Natural Sciences (Physical Sciences) and the Natural Sciences (Biological Sciences): require the ESAT.

For Chemical Engineering and Biotechnology, BA (Hons) and Meng: require the ESAT.

⁵⁶ <https://www.imperial.ac.uk/study/apply/undergraduate/process/admissions-tests/esat/>

⁵⁷ <https://www.undergraduate.study.cam.ac.uk/courses/natural-sciences-ba-hons-msci>
www.SmashingScience.org



Psychological and Behavioural Sciences, BA (Hons): “There is an admission assessment at some Colleges for this course. You do not need to register in advance. Check the [College admission assessments page](#) for more information. ...Applicants to some Colleges are required to submit written work prior to interview.”⁵⁸

Medicine, MB and Bchir⁵⁹: “You will need to take the [University Clinical Aptitude Test](#).”

University of Oxford⁶⁰ Science Subjects Entrance Exams

<p>Which course are you applying for?</p> <p>Biology</p> <p>Test(s) required</p> <p>There is no admissions test for your chosen course.</p>	<p>Which course are you applying for?</p> <p>Biomedical Sciences</p> <p>Test(s) required</p> <p>Biomedical Sciences Admissions Test</p>
<p>Which course are you applying for?</p> <p>Chemistry</p> <p>Test(s) required</p> <p>There is no admissions test for your chosen course.</p>	<p>Which course are you applying for?</p> <p>Computer Science</p> <p>Test(s) required</p> <p>MAT (Mathematics Admissions Test)</p>
<p>Which course are you applying for?</p> <p>Engineering Science</p> <p>Test(s) required</p> <p>PAT (Physics Admissions Test)</p>	<p>Which course are you applying for?</p> <p>Materials Science</p> <p>Test(s) required</p> <p>PAT (Physics Admissions Test)</p>
<p>Which course are you applying for?</p> <p>Medicine</p> <p>Test(s) required</p> <p>UCAT (University Clinical Aptitude Test)</p>	<p>Which course are you applying for?</p> <p>Medicine (graduate entry)</p> <p>Test(s) required</p> <p>UCAT (University Clinical Aptitude Test)</p>
<p>Which course are you applying for?</p> <p>Physics</p> <p>Test(s) required</p> <p>PAT (Physics Admissions Test)</p>	<p>Which course are you applying for?</p> <p>Physics and Philosophy</p> <p>Test(s) required</p> <p>PAT (Physics Admissions Test)</p>
<p>Which course are you applying for?</p> <p>Psychology (Experimental)</p> <p>Test(s) required</p> <p>TSA (Thinking Skills Assessment)</p>	<p>Which course are you applying for?</p> <p>Psychology, Philosophy and Linguistics</p> <p>Test(s) required</p> <p>TSA (Thinking Skills Assessment)</p>

⁵⁸ <https://www.undergraduate.study.cam.ac.uk/courses/psychological-behavioural-sciences-ba-hons>

⁵⁹ <https://www.undergraduate.study.cam.ac.uk/courses/medicine-mb-bchir>

⁶⁰ <https://www.ox.ac.uk/admissions/undergraduate/applying-to-oxford/guide/admissions-tests>



Appendix: Goal setting and introducing yourself at A2

Please complete this brief introduction to yourself and your background and what you hope to study later on and why.

Name, English and Chinese (in pinyin): _____ Class: _____

Intending to apply to (circle): Cambridge/Oxford Yes/No

Intending to apply for medicine? Yes/No

Have you finished your Personal Statement? Yes/No

Are you interested in tutoring AS students (chem OR biology)? Yes/No

Email address: _____

Subject	IGCSE Grade	AS Grade	AS %	A2 Target grade

What do you want to do after high school?

- What kinds of subjects might you be interested in studying at university?
- Which universities are you hoping to go to?
- What type of career, or profession, are you hoping to do after that university degree?

Rank possible subjects you might study and include what kind of career you might hope it could lead to, as well as the universities you are interested in (1 = 1st choice, your favourite, 5 = 5th choice, least favourite):

Number	Degree subject	Country	University	Career
1		UK		
2		UK		
3		UK		
4		UK		
5		UK		

Achievements, goals and interests

What are your interests outside of the classroom?

Which competitions/awards have you got (e.g. International Chemistry/Maths/Physics Olympiad etc)

Which competitions/awards do you intend to do, and date you will get the result

Which activities (at school or outside of school, like music or sport) have you done before?

What career would you like (if you are not sure yet, what careers might you be interested in?)

What are your targets (what do you hope to achieve or find out about) for the first few weeks of term?

Academic Targets for this term (and what you will do to achieve them):

What are the last 3 good books you have read?

Can you think of anything that has happened in science recently in the news that you thought was amazing?

Appendix: Organising your interview preparation

Goals for this kind of preparation for your interview

1. Be able to speak better about what you know and how you solve problems (including stronger grasp and easier use of technical language).
2. Learn more facts about your subject.
3. To understand how different parts of the subject relate to each other (understand and analyse what you know).
4. Grow your confidence thinking and speaking at the highest level in your subject at your age.
5. Learn to use your notetaking skills to learn about things that are not directly related to a lesson.

There are three main sources for finding out about your interview: the university website, the academic department website and the college you are applying to website.

Your university website:

<https://www.ox.ac.uk/admissions/undergraduate/applying-to-oxford/guide/interviews>

<https://www.undergraduate.study.cam.ac.uk/apply/after/cambridge-interviews>

Describe the additional information given here:

Your notes: _____

Describe and explain how you could use this extra information to better lead your interview preparation:

Your notes: _____

Your department website

Cambridge Natural Science – No information I can find for the interview process (searched 9/11/23), so you could use the Oxford Chemistry Department

<https://www.chem.ox.ac.uk/admissions>

Describe the additional information given here:

Your notes: _____

Describe and explain how you could use this extra information to better lead your interview preparation:

Your notes: _____

Your college website

URL:

Describe the additional information given here:

Your notes: _____

Describe and explain how you could use this extra information to better lead your interview preparation:

Your notes: _____

Organising your preparations and research for your interview

Add here your notes to yourself about the things that your chosen university has stated that you think are important to improving your performance in the interview process. You can start this process by answering these questions.

Time (when is it?):

Important dates:

1. When are you notified you have one:

Your answer:

2. When is it likely to be:

Your answer:

3. When do you get the result:

Your answer:

Their stated purposes for interviewing (how do they explain this?):

Your answer:

Their actual purposes for interviewing (if different):

Your answer:

Your purposes for this process:

Your answer:

Format of interview:

Your answer:

Additional information:

Your answer:

Content assessed in the interview process:

Your answer:

What questions to they say you need to be prepared for?

Your answer:

Describe and explain what you know about “winter pool”, (what is it, why does it exist, how could it help you etc.):

Your answer:

Add info: Online Q and A sessions with current student ambassadors (ask at least 3!):

Your Questions	Their answers
1. E.g. What helped you most when you were preparing for your interview?	
2.	
3.	
4.	
5.	
6.	

Things you have gained and learned by taking the virtual tours (if available) of:

1. Department:

Your notes: _____

2. College:

Your notes: _____

3. University:

Your notes: _____

Organising your research about the college you are applying for

College you are applying for:

Does selecting your college through “open applications” affect their expectations about how much they think you should prepare?

Your answer: _____

What are the reasons for choosing a college (see here)?

<https://www.undergraduate.study.cam.ac.uk/choosing-your-college>

<https://www.ox.ac.uk/admissions/undergraduate/colleges/do-you-choose-a-college>

Your answer: _____

What reasons should not use when choosing a college?

Your answer: _____

How do they describe themselves?

Your answer: _____

How do they describe their strengths?

Your answer: _____

How do they see themselves as different to other colleges?

Your answer: _____

How are they the same as others?

Your answer: _____

Now with all of this research try to answer these questions as fully as you can:

What skills, attributes and attitudes do you think they are more interested in seeing in their successful applicants?

Your answer: _____

What skills, attributes and attitudes will they be selecting against?

Your answer: _____

Organising your revision and learning program for your interview

In addition to general revision of ALL AS Level material, you should also be learning about A2 and slightly beyond material in the subject you are applying for.

Try to select a more junior academic from your college's staff directory, they might be more likely to be involved in the interviewing process. If you are splendidly lucky, you will have researched their work before you find out that they are interviewing you. If not, you have developed and expanded on your research skills which will allow you to more effectively and efficiently research whoever becomes your interviewer.

You are not aiming to be able to answer their hardest questions, rather you are using this interview experience to expand your science learning to A2 level and even beyond. You will also be growing your confidence levels in science.

It may be possible in some circumstances to do this process in conjunction with the teachers and or university advisor who are helping you with your UCAS application, so talk to them and ask them if they think it would be a good fit for how they prefer to coach students.

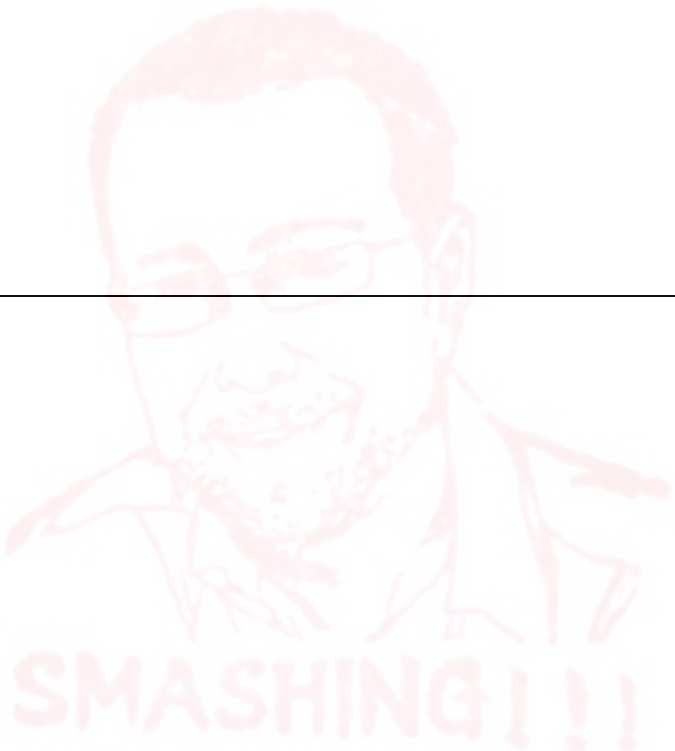
This will allow you to practice speaking what you know, as well as to help embed and consolidate your learning so that you understand it in a deeper way and are more likely to remember it for longer. This, in fact, is very much what the Oxbridge small group tutoring approach to university education is about. A major reason for the interview itself is to assess how well you would learn in a system like this, so while you are improving your ability to demonstrate your passion and understanding for your subject, you are also developing essential tutorial skills that the interviewers are strongly selecting for.


Longer term, this structured and highly organised approach to revision, learning and preparation will help you make the most competitive applications in your future, for instance, for your dream job one day.

If you find you have more time, it is better to go more deeply into one of these research projects, so learn more and better about a single topic, than to simply copy and past words into the table. You will be asked questions about this, after all, so successful work here should be measured in how well you talk about this science and answer questions, rather than how much text you pour into these tables.

Try to write in pen, or in electronic pen, it leaves a deeper impression on the brain and you can show yourself, and possibly your teacher how seriously and how hard you are working.

Name of college fellow	
Position	
Their college webpage	
Their lab's website	
Your notes about their work (3 most accessible areas)	
Most suitable area to learn more about, both at A2 and slightly beyond	
A2 CAIE Syllabus Topic name and number	

<p>A2 Summary notes on the hardest parts of this in the syllabus (2-3 paragraphs of your own writing)</p>	
<p>Notes on research, e.g. from LibreText and Wikipedia website going a little beyond the A2 syllabus (2-3 paragraphs of describing and explaining with your own words)</p>	

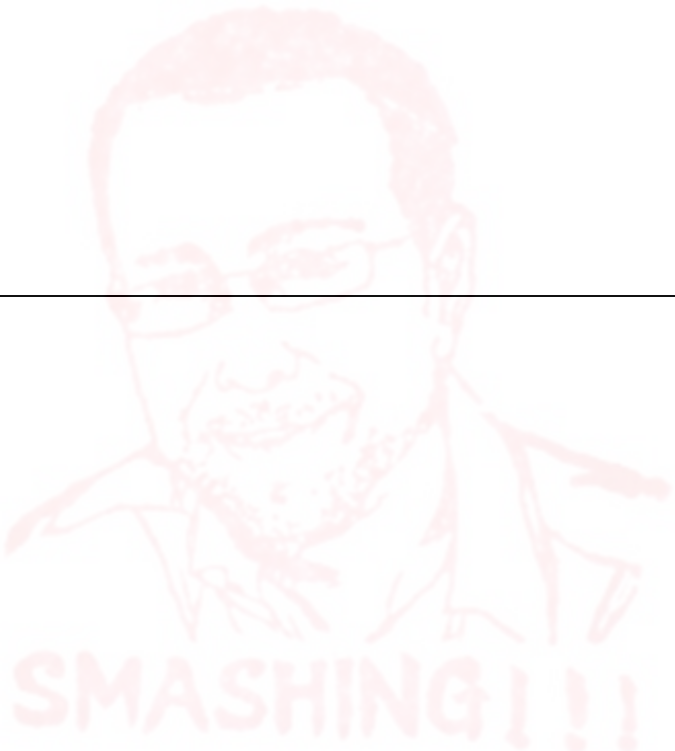
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Name of college fellow	
Position	
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Your notes about their work (3 most accessible areas)	
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Most suitable area to learn more about, both at A2 and slightly beyond	
A2 CAIE Syllabus Topic name and number	
A2 Summary notes on the hardest parts of this in the syllabus (2-3 paragraphs of your own writing)	
Notes on research, e.g. from LibreText and Wikipedia website going a little beyond the A2 syllabus (2-3 paragraphs of describing and explaining with your own words)	

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Appendix Mock Interview Feedback Form

This is one example of a kind of feedback form that you might get after a mock interview. It can help you by highlighting areas where you can improve, and what you could do to become better at this skill. Ticks in the *Interview skill/ability* box indicate a proven example of that skill in that interview, if the Yes is circled in the *Do you need to improve?* box you can think about the things suggested in the *What you can do to improve this skill*.

General interview kinds of skills are in italics and highlighted in grey (address the most predictable questions), **academic abilities are in bold** (usually more commonly tested in interviews). If the **skill can be tested by both types of interviews question it is both grey and bold**.

Student name:

Type of interview: Academic/General

Universities interested in:

Course:

Areas to improve:

Interview skill/ability	What you can do to improve this skill	Do you need to improve?
<i>Understanding of course structure</i>	<i>Find out essential details about your course from the university website.</i>	Yes
<i>Ability to explain well why you applied to Oxford/Cambridge/Imperial</i>	<i>Make sure your answers to predictable questions often asked are filled with details of things you have learnt; these will demonstrate that you are an enthusiastic student that wants to find answers because of your curiosity. You are interested in finding out how and why things work.</i>	Yes
<i>Ability to explain why you chose your college</i>	<i>Find out details about a science researcher and learn about how that relates.</i>	Yes
<i>Ability to explain why you chose your subject at university</i>	<i>This is an excellent opportunity to explain through the details you provide that you are curious about the subject and knowledgeable. A strong personal answer could even deliver a demonstration of your excitement about your subject.</i>	Yes
Ability to display outside reading	Some questions, like why Cambridge/Chemistry are easier to show this than others.	Yes
Curiosity in science	Questions where you do not know the answer are straightforward to display your curiosity, but it is a really difficult skill to show, especially if it isn't really there. But you can build your curiosity through hard work and commitment, but it takes time and a great deal of passion for excellence to grow, but perhaps the most valuable skill to have at university.	Yes
Ability to answer the question asked, and not talk about not relevant	Think carefully before you answer, and never pretend you have misunderstood the question. At best, you are wasting your own interview time, at worst you are demonstrating an ability to be dishonest.	Yes
Ability to demonstrate a quick honesty when you don't know the answer	Think about the question and if you discover you don't have the answer, your next thing you need to help deliver the answer is to ask for help. If you waste time thinking about something with almost no chance of success you are demonstrating an inability to work effectively with ideas you are unfamiliar with. This is at the core of what these interviews are trying to find out about you.	Yes



Interview skill/ability	What you can do to improve this skill	Do you need to improve?
Confidence	Strong, consistent success at A level can help, but so too will talking to others effectively. Confidence is all about knowing your limits and working within them. Arrogance is the opposite, not knowing your limits and working beyond them. Being good at AS level compared to others in your school is very different from being a strong Oxbridge candidate.	Yes
Strong English listening skills	Talk to your teachers in English about their subject, often and regularly. Talk to your friends and classmates in English about your favourite subjects, often and regularly.	Yes
Strong English-speaking skills	Talk to your teachers in English about their subject, often and regularly. Talk to your friends and classmates in English about your favourite subjects, often and regularly.	Yes
Waiting before you start to talk to think through the structure of your answer	Record yourself speaking your answer to a 3- or 4-mark exam question (either Paper 2 or even Paper 4), ideally without writing down anything. You can start with easier 1-mark questions. If it is a calculations question, you should also write out our answer.	Yes
Speaking out loud what you are thinking when you start answering a question	Mock interview practice is especially useful for this.	Yes
Ability to ask for help early and interact effectively with hints	Asking for help allows you to demonstrate a quickness and clarity of thought, and asking well for hints shows you can learn in the tutorial system which Oxbridge uses to teach undergraduates.	Yes
Ability to display strong command of subject syllabus knowledge	Sit your A2 exams in November (or at least plan and prepare to) and do the work necessary to get a strong A* at least in the subject you are applying to university for.	Yes
Ability to talk about larger and more complex science ideas effectively and in English	Talk to your teachers in English about their subject, often and regularly. Talk to your friends and classmates in English about your favourite subjects, often and regularly.	Yes
Understanding of the scientific method	Papes 3 and 5 (any science A Level) can help.	Yes
Ease and accuracy of use of technical terms	When you are talking with your teachers and friends, try to introduce 2 or 3 new technical terms into a conversation. Plan this before your conversation.	Yes
Ability to learn new information in the interview	This is a skill connected to learning, confidence and experience. A large amount of experience talking with knowledgeable people about things you are less knowledgeable can help. A wide and deep outside interest (curiosity) in your subject, for instance always and often watching excellent documentaries your whole life.	Yes

Appendix: Organising your best reference

Your reference will be about you and should include the best things you have done. It is vital that you help whoever is writing your reference write the best possible one they can.

In addition to giving them your personal statement answers to some or all of these questions will help!

Some of these questions you can also ask yourself at the start of your AS year, **and before you write your personal statement**, if you struggle to answer them well, then **GET ACTIVE** and do the things needed to allow you to answer them well!

Try to answer these questions as well as you can, with as much detail as possible. This form will help make all of the extra things you have done inside and outside of school help make your university application even better!

Name, English and Chinese (in pinyin): _____ Class: _____

Email address: _____

Which subject is writing your references (usually the subject you are applying for at degree level): _____

Which teacher is writing it? _____ Have you spoken to them about this? Yes/No

Getting to know your Choices.

1. **Where** do you want to study?

Answer:

2. **What:** first choice subject?

Answer:

3. Second and third choice subjects (if any)?

Answer:

4. What do you **like** most about that subject?

Answer:

5. What has happened that you find interesting in this field? (What's been in the news?)

Answer:

6. Top 3 ideas for a career?

Answer:

7. Why do you want to pursue your top career choices?

Answer:

Getting to know your Interests

8. What have you done, seen, experienced that makes you more interested in this subject choice?

Answer:

9. What do you **like most** about studying this subject at A Level?

Answer:

10. What do you find most **interesting** about this subject and why?

Answer:

11. What was the **last interesting** conversation you had with your teacher in your subject of interest?
Answer:
12. What was the **most interesting** conversation you had with you teacher in your subject of interest?
Answer:
13. How often do you talk about this subject with your friends?
Answer:
14. What are the top 3 **biggest ideas** you have encountered?
Answer:
15. What are the **3 most important** ideas to you that you have ever thought about?
Answer:
16. What are your 3 favourite books you have read?
Answer:
17. What are the 3 most important books to your development of your mind, that have had the biggest impact on how you think that you have read?
Answer:

Getting to know your Achievements

18. What achievements do you have within the school? (e.g. helping out with school events, promoting the school, mentoring students, participating in events like maths day etc.).
Answer:
19. Are you a member of any societies?
Answer:
20. Have you lead any societies? How?
Answer:
21. Have you achieved anything important with any society that you worked really hard at and are really proud of?
Answer:
22. What after school events, like plays or sports competitions have you participated in? What did you learn from those experiences?
Answer:
23. What are the top 3 reasons for going to or experiences you want to get out of your time at university?
Answer:
24. When you imagine yourself after succeeding at university, how are you different? How are you the same?
Answer:
25. What are the 3 things you are most proud about yourself?
Answer:

Name:

Class:

Date:

Achievements

Include anything like academics/school involvements, school productions, music performances, extracurricular activities: summer school, research project, school clubs, internship, community service, sports, skills, hobbies. Rank them according to how important you think they are (1=most important, 5 least important).

Your Rank	Grade	Hour/week	Week/year	Activity Type	Year/Break	Organization Name	Position	Activity Description
1	11	21	4	Academic	Summer break	Summer school with topic ****	Participant	<p>Took lessons in *** taught by ***.</p> <p>Made 2 projects: *** & ***, which I presented to a group of 30 students and teachers at the end of the course.</p> <p>Achievements/what you took away from it: Worked as a team to learn about a topic beyond the syllabus for 3 weeks at a university in a city that I do not live in. Learnt the importance of effective and timely communication when working towards a deadline in a group setting with highly competitive people.</p>



Your Rank	Grade	Hour/ week	Week /year	Activity Type	Year/ Break	Organization Name	Position	Activity Description

Competitions and Awards

Rank	Grade Level	Year	Honor Title	Awards	Level(s) of recognition	Additional notes
1	10	2020	UKMT Senior Mathematical Challenge	Merit	National	



Getting to know what you think about yourself

Be sure to give concrete examples to back up more general statements. Specificity is very important in a letter of recommendation.

And be as positive about yourself as possible!

Intellectual ability

Think about: overall intelligence, analytical skills, creativity, academic record, retention of information.

Answer:

Performance in class

Think about depth and breadth of knowledge, grade results, ability to analyze and apply what you have learnt

Answer:

Communication skills

Writing skills (what did you write?), spoken skills, e.g. in presentations given

Answer:

Self-discipline

To what extent are you persistent, efficient and motivated? Are you able to work independently?

Answer:

Personal qualities

Industry, self-discipline, motivation, maturity, initiative, flexibility, leadership qualities, team working skills, perseverance, energy, competitiveness, etc.

Answer:

Most important strengths and weaknesses

What do you expect to achieve at university. What things are you excited about doing whilst there?

Answer:

Any other things that make you stand out

Anything that is unique, important and good

Answer:

Getting to know your education history:

When did you come to High School?

Answer:

What's your primary and secondary school? Are they international schools or domestic schools?

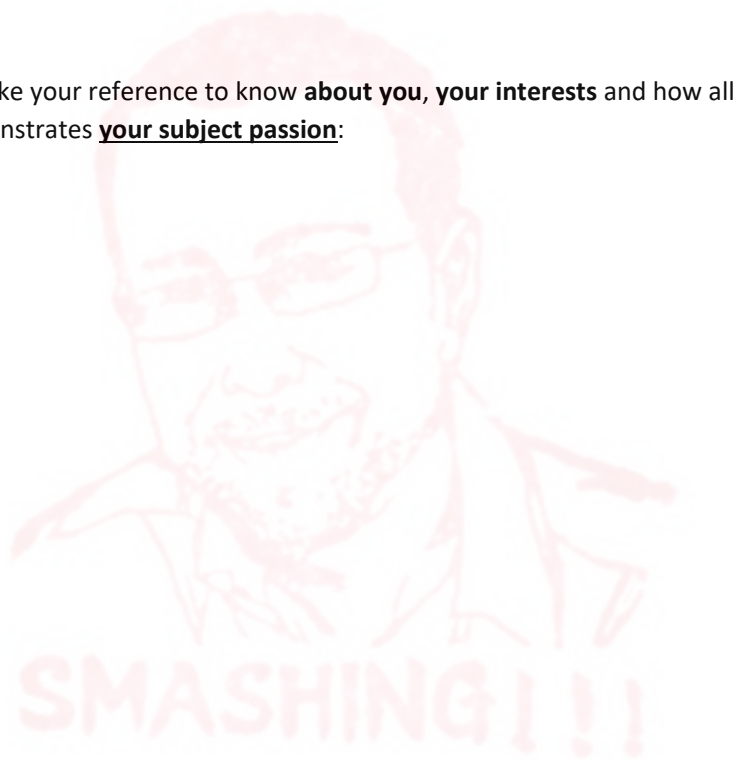
Answer:

When did you decide to study abroad?

Answer:

Final opportunity

Further information you would like your reference to know **about you, your interests** and how all of this relates to **things you have done** that demonstrates **your subject passion**:



Getting to know what is on your UCAS form:

Intended degree subjects:

Number	Degree subject	Country	University
1		UK	
2		UK	
3		UK	
4		UK	
5		UK	

Grades

For the final column “Confirmed?”, write yes if you have spoken to the teacher who is responsible for making that prediction and they are 100% sure they will give you that prediction.

Subject	iGCSE Grade	AS Grade	AS %	A2 Target grade	Predicted A Level grade	100% Confirmed?

If any of your predictions have not been 100% confirmed, add any additional details here that you would like your reference to know about:

Discussions with your referee

Ways to make talking with your teachers more positive and more productive:

- Talking with people in your life like teachers is a skill, if you find it difficult, don't worry, you just need to build this skill through careful practice!
- Be respectful, you are asking someone for something, their time, that they usually have very little of!
- Choose your time to ask them for their time carefully. Ask them “are you are free to talk now?”, if they are usually busy, **ask them when they prefer to talk.**
- Write out what you would like to ask them, using the table that follows. This can help you feel less nervous. It will also mean that you are thinking much harder about your subject (active learning) which will improve your academic performance.
- Prepare your questions, based on what was taught last lesson, or recently. Try to pick a subtopic your teacher is obviously interested.
- Try to make your questions open ended, giving them the freedom to talk about their passion. Avoid questions like how many atoms are in the amino acid tryptophan, instead pick up on something they said in class “you said that tryptophan is an essential amino acid, what makes it essential?”
- The easiest kinds of questions are connected to what they like most about what they are teaching now, or what they teach in general.
- You should not be trying to catch them out, or get them onto parts of a subject they are less comfortable with. You want at the end of this for them to have the evidence to suggest that they think you would fit in well in any future academic setting. If you are going out of your way to make their work life more difficult than you are making it harder for them to write you a good reference, the opposite of a good idea.
- Start early, ideally at the start of your AS year! If you do, just one question a week per teacher will deliver a whole year's worth of outstanding engagement in all subjects form you
- As you get more experience talking to a teacher, try to talk to your other teachers. You might discover that they are quite different people when you take the care to get to know them! Showing an interest in your studies can also really help build positive and productive relationships that can prevent all kinds of problems that come from misunderstandings. You will also be building your skills in forming and maintaining professional relationships, a key life skill.
- Getting good at asking interesting questions is the essence of a thoughtful intellectual, and will help you stand out, even in the most intellectually competitive environments, like university and beyond.

Record of your conversations with your teacher in this table

Date	Day	Time	Topic discussed	Questions you asked, and the answers you got
26 th Aug	Monday	Afterschool, 4:45pm	T12: Energy and respiration	Could life ever be an endothermic process? Last lesson you mentioned that aerobic respiration using oxygen took a long time to evolve, why? What was the Great Oxidation Event (GOE) 2.4 billion years ago you mentioned last lesson? Why might human egg cells NOT have mitochondria?

Ideally this form should be typed out, but it could also easily just be used written out by hand.

To download an electronic version of the activities in MS Word format scan this:

File name: *Oxford, Cambridge and Top 20 University UCAS **Activities ONLY***



Or go here: <https://www.smashingscience.org/uni-guidance>
www.SmashingScience.org

Patrick Brannac

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