READING

READING PASSAGE 1

*You should spend about 20 minutes on **Questions 1–13**, which are based on Reading Passage 1 below.*

The development of the London underground railway

In the first half of the 1800s, London's population grew at an astonishing rate, and the central area became increasingly congested. In addition, the expansion of the overground railway network resulted in more and more passengers arriving in the capital. However, in 1846, a Royal Commission decided that the railways should not be allowed to enter the City, the capital's historic and business centre. The result was that the overground railway stations formed a ring around the City. The area within consisted of poorly built, overcrowded slums and the streets were full of horse-drawn traffic. Crossing the City became a nightmare. It could take an hour and a half to travel 8 km by horse-drawn carriage or bus. Numerous schemes were proposed to resolve these problems, but few succeeded.

Amongst the most vocal advocates for a solution to London's traffic problems was Charles Pearson, who worked as a solicitor for the City of London. He saw both social and economic advantages in building an underground railway that would link the overground railway stations together and clear London slums at the same time. His idea was to relocate the poor workers who lived in the inner-city slums to newly constructed suburbs, and to provide cheap rail travel for them to get to work. Pearson's ideas gained support amongst some businessmen and in 1851 he submitted a plan to Parliament. It was rejected, but coincided with a proposal from another group for an underground connecting line, which Parliament passed.

The two groups merged and established the Metropolitan Railway Company in August 1854. The company's plan was to construct an underground railway line from the Great Western Railway's (GWR) station at Paddington to the edge of the City at Farringdon Street – a distance of almost 5 km. The organisation had difficulty in raising the funding for such a radical and expensive scheme, not least because of the critical articles printed by the press. Objectors argued that the tunnels would collapse under the weight of traffic overhead, buildings would be shaken and passengers would be poisoned by the emissions from the train engines. However, Pearson and his partners persisted.

The GWR, aware that the new line would finally enable them to run trains into the heart of the City, invested almost £250,000 in the scheme. Eventually, over a five-year period, £1m was raised. The chosen route ran beneath existing main roads to minimise the expense of

demolishing buildings. Originally scheduled to be completed in 21 months, the construction of the underground line took three years. It was built just below street level using a technique known as ‘cut and cover’. A trench about ten metres wide and six metres deep was dug, and the sides temporarily held up with timber beams. Brick walls were then constructed, and finally a brick arch was added to create a tunnel. A two-metre-deep layer of soil was laid on top of the tunnel and the road above rebuilt.

The Metropolitan line, which opened on 10 January 1863, was the world’s first underground railway. On its first day, almost 40,000 passengers were carried between Paddington and Farringdon, the journey taking about 18 minutes. By the end of the Metropolitan’s first year of operation, 9.5 million journeys had been made.

Even as the Metropolitan began operation, the first extensions to the line were being authorised; these were built over the next five years, reaching Moorgate in the east of London and Hammersmith in the west. The original plan was to pull the trains with steam locomotives, using firebricks in the boilers to provide steam, but these engines were never introduced. Instead, the line used specially designed locomotives that were fitted with water tanks in which steam could be condensed. However, smoke and fumes remained a problem, even though ventilation shafts were added to the tunnels.

Despite the extension of the underground railway, by the 1880s, congestion on London’s streets had become worse. The problem was partly that the existing underground lines formed a circuit around the centre of London and extended to the suburbs, but did not cross the capital’s centre. The ‘cut and cover’ method of construction was not an option in this part of the capital. The only alternative was to tunnel deep underground.

Although the technology to create these tunnels existed, steam locomotives could not be used in such a confined space. It wasn’t until the development of a reliable electric motor, and a means of transferring power from the generator to a moving train, that the world’s first deep-level electric railway, the City & South London, became possible. The line opened in 1890, and ran from the City to Stockwell, south of the River Thames. The trains were made up of three carriages and driven by electric engines. The carriages were narrow and had tiny windows just below the roof because it was thought that passengers would not want to look out at the tunnel walls. The line was not without its problems, mainly caused by an unreliable power supply. Although the City & South London Railway was a great technical achievement, it did not make a profit. Then, in 1900, the Central London Railway, known as the ‘Tuppenny Tube’, began operation using new electric locomotives. It was very popular and soon afterwards new railways and extensions were added to the growing tube network. By 1907, the heart of today’s Underground system was in place.

Questions 1–6

Complete the notes below.

*Choose **ONE WORD ONLY** from the passage for each answer.*

Write your answers in boxes 1–6 on your answer sheet.

The London underground railway

The problem

- The **1** ..... of London increased rapidly between 1800 and 1850
- The streets were full of horse-drawn vehicles

The proposed solution

- Charles Pearson, a solicitor, suggested building an underground railway
- Building the railway would make it possible to move people to better housing in the **2** .....
- A number of **3** ..... agreed with Pearson's idea
- The company initially had problems getting the **4** ..... needed for the project
- Negative articles about the project appeared in the **5** .....

The construction

- The chosen route did not require many buildings to be pulled down
- The 'cut and cover' method was used to construct the tunnels
- With the completion of the brick arch, the tunnel was covered with **6** .....

Questions 7–13

Do the following statements agree with the information given in Reading Passage 1?

In boxes 7–13 on your answer sheet, write

TRUE	*if the statement agrees with the information*
FALSE	*if the statement contradicts the information*
NOT GIVEN	*if there is no information on this*

7 Other countries had built underground railways before the Metropolitan line opened.

8 More people than predicted travelled on the Metropolitan line on the first day.

9 The use of ventilation shafts failed to prevent pollution in the tunnels.

10 A different approach from the 'cut and cover' technique was required in London's central area.

11 The windows on City & South London trains were at eye level.

12 The City & South London Railway was a financial success.

13 Trains on the 'Tuppenny Tube' nearly always ran on time.

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READING PASSAGE 2

*You should spend about 20 minutes on **Questions 14–26**, which are based on Reading Passage 2 below.*

Stadiums: past, present and future

A Stadiums are among the oldest forms of urban architecture: vast stadiums where the public could watch sporting events were at the centre of western city life as far back as the ancient Greek and Roman Empires, well before the construction of the great medieval cathedrals and the grand 19th- and 20th-century railway stations which dominated urban skylines in later eras.

Today, however, stadiums are regarded with growing scepticism. Construction costs can soar above £1 billion, and stadiums finished for major events such as the Olympic Games or the FIFA World Cup have notably fallen into disuse and disrepair.

But this need not be the case. History shows that stadiums can drive urban development and adapt to the culture of every age. Even today, architects and planners are finding new ways to adapt the mono-functional sports arenas which became emblematic of modernisation during the 20th century.

B The amphitheatre* of Arles in southwest France, with a capacity of 25,000 spectators, is perhaps the best example of just how versatile stadiums can be. Built by the Romans in 90 AD, it became a fortress with four towers after the fifth century, and was then transformed into a village containing more than 200 houses. With the growing interest in conservation during the 19th century, it was converted back into an arena for the staging of bullfights, thereby returning the structure to its original use as a venue for public spectacles.

Another example is the imposing arena of Verona in northern Italy, with space for 30,000 spectators, which was built 60 years before the Arles amphitheatre and 40 years before Rome's famous Colosseum. It has endured the centuries and is currently considered one of the world's prime sites for opera, thanks to its outstanding acoustics.

C The area in the centre of the Italian town of Lucca, known as the Piazza dell'Anfiteatro, is yet another impressive example of an amphitheatre becoming absorbed into the fabric of the city. The site evolved in a similar way to Arles and was progressively filled with buildings from the Middle Ages until the 19th century, variously used as houses, a salt depot and a prison. But rather than reverting to an arena, it became a market square, designed by Romanticist architect Lorenzo Nottolini. Today, the ruins of the amphitheatre remain embedded in the various shops and residences surrounding the public square.

D There are many similarities between modern stadiums and the ancient amphitheatres intended for games. But some of the flexibility was lost at the beginning of the 20th century, as stadiums were developed using new products such as steel and reinforced concrete, and made use of bright lights for night-time matches.

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* amphitheatre: (especially in Greek and Roman architecture) an open circular or oval building with a central space surrounded by tiers of seats for spectators, for the presentation of dramatic or sporting events

Many such stadiums are situated in suburban areas, designed for sporting use only and surrounded by parking lots. These factors mean that they may not be as accessible to the general public, require more energy to run and contribute to urban heat.

E But many of today's most innovative architects see scope for the stadium to help improve the city. Among the current strategies, two seem to be having particular success: the stadium as an urban hub, and as a power plant.

There's a growing trend for stadiums to be equipped with public spaces and services that serve a function beyond sport, such as hotels, retail outlets, conference centres, restaurants and bars, children's playgrounds and green space. Creating mixed-use developments such as this reinforces compactness and multi-functionality, making more efficient use of land and helping to regenerate urban spaces.

This opens the space up to families and a wider cross-section of society, instead of catering only to sportspeople and supporters. There have been many examples of this in the UK: the mixed-use facilities at Wembley and Old Trafford have become a blueprint for many other stadiums in the world.

F The phenomenon of stadiums as power stations has arisen from the idea that energy problems can be overcome by integrating interconnected buildings by means of a smart grid, which is an electricity supply network that uses digital communications technology to detect and react to local changes in usage, without significant energy losses. Stadiums are ideal for these purposes, because their canopies have a large surface area for fitting photovoltaic panels and rise high enough (more than 40 metres) to make use of micro wind turbines.

Freiburg Mage Solar Stadium in Germany is the first of a new wave of stadiums as power plants, which also includes the Amsterdam Arena and the Kaohsiung Stadium. The latter, inaugurated in 2009, has 8,844 photovoltaic panels producing up to 1.14 GWh of electricity annually. This reduces the annual output of carbon dioxide by 660 tons and supplies up to 80 percent of the surrounding area when the stadium is not in use. This is proof that a stadium can serve its city, and have a decidedly positive impact in terms of reduction of CO_2 emissions.

G Sporting arenas have always been central to the life and culture of cities. In every era, the stadium has acquired new value and uses: from military fortress to residential village, public space to theatre and most recently a field for experimentation in advanced engineering. The stadium of today now brings together multiple functions, thus helping cities to create a sustainable future.

Questions 14–17

Reading Passage 2 has seven sections, **A–G**.

Which section contains the following information?

*Write the correct letter, **A–G**, in boxes 14–17 on your answer sheet.*

NB *You may use any letter more than once.*

14 a mention of negative attitudes towards stadium building projects

15 figures demonstrating the environmental benefits of a certain stadium

16 examples of the wide range of facilities available at some new stadiums

17 reference to the disadvantages of the stadiums built during a certain era

Questions 18–22

Complete the summary below.

*Choose **ONE WORD ONLY** from the passage for each answer.*

Write your answers in boxes 18–22 on your answer sheet.

Roman amphitheatres

The Roman stadiums of Europe have proved very versatile. The amphitheatre of Arles, for example, was converted first into a **18** ……, then into a residential area and finally into an arena where spectators could watch **19** ……. Meanwhile, the arena in Verona, one of the oldest Roman amphitheatres, is famous today as a venue where **20** …… is performed. The site of Lucca's amphitheatre has also been used for many purposes over the centuries, including the storage of **21** ……. It is now a market square with **22** …… and homes incorporated into the remains of the Roman amphitheatre.

Questions 23 and 24

*Choose **TWO** letters, **A–E**.*

Write the correct letters in boxes 23 and 24 on your answer sheet.

When comparing twentieth-century stadiums to ancient amphitheatres in Section D, which **TWO** negative features does the writer mention?

A They are less imaginatively designed.
B They are less spacious.
C They are in less convenient locations.
D They are less versatile.
E They are made of less durable materials.

Questions 25 and 26

*Choose **TWO** letters, **A–E**.*

Write the correct letters in boxes 25 and 26 on your answer sheet.

Which **TWO** advantages of modern stadium design does the writer mention?

A offering improved amenities for the enjoyment of sports events
B bringing community life back into the city environment
C facilitating research into solar and wind energy solutions
D enabling local residents to reduce their consumption of electricity
E providing a suitable site for the installation of renewable power generators

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READING PASSAGE 3

*You should spend about 20 minutes on **Questions 27–40**, which are based on Reading Passage 3 below.*

To catch a king

Anna Keay reviews Charles Spencer's book about the hunt for King Charles II during the English Civil War of the seventeenth century

Charles Spencer's latest book, *To Catch a King*, tells us the story of the hunt for King Charles II in the six weeks after his resounding defeat at the Battle of Worcester in September 1651. And what a story it is. After his father was executed by the Parliamentarians in 1649, the young Charles II sacrificed one of the very principles his father had died for and did a deal with the Scots, thereby accepting Presbyterianism* as the national religion in return for being crowned King of Scots. His arrival in Edinburgh prompted the English Parliamentary army to invade Scotland in a pre-emptive strike. This was followed by a Scottish invasion of England. The two sides finally faced one another at Worcester in the west of England in 1651. After being comprehensively defeated on the meadows outside the city by the Parliamentarian army, the 21-year-old king found himself the subject of a national manhunt, with a huge sum offered for his capture. Over the following six weeks he managed, through a series of heart-poundingly close escapes, to evade the Parliamentarians before seeking refuge in France. For the next nine years, the penniless and defeated Charles wandered around Europe with only a small group of loyal supporters.

Years later, after his restoration as king, the 50-year-old Charles II requested a meeting with the writer and diarist Samuel Pepys. His intention when asking Pepys to commit his story to paper was to ensure that this most extraordinary episode was never forgotten. Over two three-hour sittings, the king related to him in great detail his personal recollections of the six weeks he had spent as a fugitive. As the king and secretary settled down (a scene that is surely a gift for a future scriptwriter), Charles commenced his story: 'After the battle was so absolutely lost as to be beyond hope of recovery, I began to think of the best way of saving myself.'

One of the joys of Spencer's book, a result not least of its use of Charles II's own narrative as well as those of his supporters, is just how close the reader gets to the action. The day-by-day retelling of the fugitives' doings provides delicious details: the cutting of the king's long hair with agricultural shears, the use of walnut leaves to dye his pale skin, and the day Charles spent lying on a branch of the great oak tree in Boscobel Wood as the Parliamentary soldiers scoured the forest floor below. Spencer draws out both the humour – such as the preposterous refusal of Charles's friend Henry Wilmot to adopt disguise on the grounds that it was beneath his dignity – and the emotional tension when the secret of the king's presence was cautiously revealed to his supporters.

* Presbyterianism: part of the reformed Protestant religion

Charles's adventures after losing the Battle of Worcester hide the uncomfortable truth that whilst almost everyone in England had been appalled by the execution of his father, they had not welcomed the arrival of his son with the Scots army, but had instead firmly bolted their doors. This was partly because he rode at the head of what looked like a foreign invasion force and partly because, after almost a decade of civil war, people were desperate to avoid it beginning again. This makes it all the more interesting that Charles II himself loved the story so much ever after. As well as retelling it to anyone who would listen, causing eye-rolling among courtiers, he set in train a series of initiatives to memorialise it. There was to be a new order of chivalry, the Knights of the Royal Oak. A series of enormous oil paintings depicting the episode were produced, including a two-metre-wide canvas of Boscobel Wood and a set of six similarly enormous paintings of the king on the run. In 1660, Charles II commissioned the artist John Michael Wright to paint a flying squadron of cherubs* carrying an oak tree to the heavens on the ceiling of his bedchamber. It is hard to imagine many other kings marking the lowest point in their life so enthusiastically, or indeed pulling off such an escape in the first place.

Charles Spencer is the perfect person to pass the story on to a new generation. His pacey, readable prose steers deftly clear of modern idioms and elegantly brings to life the details of the great tale. He has even-handed sympathy for both the fugitive king and the fierce republican regime that hunted him, and he succeeds in his desire to explore far more of the background of the story than previous books on the subject have done. Indeed, the opening third of the book is about how Charles II found himself at Worcester in the first place, which for some will be reason alone to read *To Catch a King*.

The tantalising question left, in the end, is that of what it all meant. Would Charles II have been a different king had these six weeks never happened? The days and nights spent in hiding must have affected him in some way. Did the need to assume disguises, to survive on wit and charm alone, to use trickery and subterfuge to escape from tight corners help form him? This is the one area where the book doesn't quite hit the mark. Instead its depiction of Charles II in his final years as an ineffective, pleasure-loving monarch doesn't do justice to the man (neither is it accurate), or to the complexity of his character. But this one niggle aside, *To Catch a King* is an excellent read, and those who come to it knowing little of the famous tale will find they have a treat in store.

* cherub: an image of angelic children used in paintings

Questions 27–31

Complete the summary using the list of phrases, ***A–J****, below.*

Write the correct letter, ***A–J****, in boxes 27–31 on your answer sheet.*

The story behind the hunt for Charles II

Charles II's father was executed by the Parliamentarian forces in 1649. Charles II then formed a **27** ..... with the Scots, and in order to become King of Scots, he abandoned an important **28** ..... that was held by his father and had contributed to his father's death. The opposing sides then met outside Worcester in 1651. The battle led to a **29** ..... for the Parliamentarians and Charles had to flee for his life. A **30** ..... was offered for Charles's capture, but after six weeks spent in hiding, he eventually managed to reach the **31** ..... of continental Europe.

A	military innovation	**B**	large reward	**C**	widespread conspiracy
D	relative safety	**E**	new government	**F**	decisive victory
G	political debate	**H**	strategic alliance	**I**	popular solution
J	religious conviction				

Questions 32–35

Do the following statements agree with the claims of the writer in Reading Passage 3?

In boxes 32–35 on your answer sheet, write

YES	*if the statement agrees with the claims of the writer*
NO	*if the statement contradicts the claims of the writer*
NOT GIVEN	*if it is impossible to say what the writer thinks about this*

32 Charles chose Pepys for the task because he considered him to be trustworthy.

33 Charles's personal recollection of the escape lacked sufficient detail.

34 Charles indicated to Pepys that he had planned his escape before the battle.

35 The inclusion of Charles's account is a positive aspect of the book.

Questions 36–40

*Choose the correct letter, **A**, **B**, **C** or **D**.*

Write the correct letter in boxes 36–40 on your answer sheet.

36 What is the reviewer's main purpose in the first paragraph?

A to describe what happened during the Battle of Worcester
B to give an account of the circumstances leading to Charles II's escape
C to provide details of the Parliamentarians' political views
D to compare Charles II's beliefs with those of his father

37 Why does the reviewer include examples of the fugitives' behaviour in the third paragraph?

A to explain how close Charles II came to losing his life
B to suggest that Charles II's supporters were badly prepared
C to illustrate how the events of the six weeks are brought to life
D to argue that certain aspects are not as well known as they should be

38 What point does the reviewer make about Charles II in the fourth paragraph?

A He chose to celebrate what was essentially a defeat.
B He misunderstood the motives of his opponents.
C He aimed to restore people's faith in the monarchy.
D He was driven by a desire to be popular.

39 What does the reviewer say about Charles Spencer in the fifth paragraph?

A His decision to write the book comes as a surprise.
B He takes an unbiased approach to the subject matter.
C His descriptions of events would be better if they included more detail.
D He chooses language that is suitable for a twenty-first-century audience.

40 When the reviewer says the book 'doesn't quite hit the mark', she is making the point that

A it overlooks the impact of events on ordinary people.
B it lacks an analysis of prevalent views on monarchy.
C it omits any references to the deceit practised by Charles II during his time in hiding.
D it fails to address whether Charles II's experiences had a lasting influence on him.

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READING

READING PASSAGE 1

*You should spend about 20 minutes on **Questions 1–13**, which are based on Reading Passage 1 below.*

The Dead Sea Scrolls

In late 1946 or early 1947, three Bedouin teenagers were tending their goats and sheep near the ancient settlement of Qumran, located on the northwest shore of the Dead Sea in what is now known as the West Bank. One of these young shepherds tossed a rock into an opening on the side of a cliff and was surprised to hear a shattering sound. He and his companions later entered the cave and stumbled across a collection of large clay jars, seven of which contained scrolls with writing on them. The teenagers took the seven scrolls to a nearby town where they were sold for a small sum to a local antiquities dealer. Word of the find spread, and Bedouins and archaeologists eventually unearthed tens of thousands of additional scroll fragments from 10 nearby caves; together they make up between 800 and 900 manuscripts. It soon became clear that this was one of the greatest archaeological discoveries ever made.

The origin of the Dead Sea Scrolls, which were written around 2,000 years ago between 150 BCE and 70 CE, is still the subject of scholarly debate even today. According to the prevailing theory, they are the work of a population that inhabited the area until Roman troops destroyed the settlement around 70 CE. The area was known as Judea at that time, and the people are thought to have belonged to a group called the Essenes, a devout Jewish sect.

The majority of the texts on the Dead Sea Scrolls are in Hebrew, with some fragments written in an ancient version of its alphabet thought to have fallen out of use in the fifth century BCE. But there are other languages as well. Some scrolls are in Aramaic, the language spoken by many inhabitants of the region from the sixth century BCE to the siege of Jerusalem in 70 CE. In addition, several texts feature translations of the Hebrew Bible into Greek.

The Dead Sea Scrolls include fragments from every book of the Old Testament of the Bible except for the Book of Esther. The only entire book of the Hebrew Bible preserved among the manuscripts from Qumran is Isaiah; this copy, dated to the first century BCE, is considered the earliest biblical manuscript still in existence. Along with biblical texts, the scrolls include documents about sectarian regulations and religious writings that do not appear in the Old Testament.

The writing on the Dead Sea Scrolls is mostly in black or occasionally red ink, and the scrolls themselves are nearly all made of either parchment (animal skin) or an early form of paper called 'papyrus'. The only exception is the scroll numbered 3Q15, which was created out of a combination of copper and tin. Known as the Copper Scroll, this curious document features letters chiselled onto metal – perhaps, as some have theorized, to better withstand the passage of time. One of the most intriguing manuscripts from Qumran, this is a sort of ancient treasure map that lists dozens of gold and silver caches. Using an unconventional vocabulary and odd spelling, it describes 64 underground hiding places that supposedly contain riches buried for safekeeping. None of these hoards have been recovered, possibly because the Romans pillaged Judea during the first century CE. According to various hypotheses, the treasure belonged to local people, or was rescued from the Second Temple before its destruction or never existed to begin with.

Some of the Dead Sea Scrolls have been on interesting journeys. In 1948, a Syrian Orthodox archbishop known as Mar Samuel acquired four of the original seven scrolls from a Jerusalem shoemaker and part-time antiquity dealer, paying less than $100 for them. He then travelled to the United States and unsuccessfully offered them to a number of universities, including Yale. Finally, in 1954, he placed an advertisement in the business newspaper *The Wall Street Journal* – under the category 'Miscellaneous Items for Sale' – that read: 'Biblical Manuscripts dating back to at least 200 B.C. are for sale. This would be an ideal gift to an educational or religious institution by an individual or group.' Fortunately, Israeli archaeologist and statesman Yigael Yadin negotiated their purchase and brought the scrolls back to Jerusalem, where they remain to this day.

In 2017, researchers from the University of Haifa restored and deciphered one of the last untranslated scrolls. The university's Eshbal Ratson and Jonathan Ben-Dov spent one year reassembling the 60 fragments that make up the scroll. Deciphered from a band of coded text on parchment, the find provides insight into the community of people who wrote it and the 364-day calendar they would have used. The scroll names celebrations that indicate shifts in seasons and details two yearly religious events known from another Dead Sea Scroll. Only one more known scroll remains untranslated.

Questions 1–5

Complete the notes below.

*Choose **ONE WORD ONLY** from the passage for each answer.*

Write your answers in boxes 1–5 on your answer sheet.

The Dead Sea Scrolls

Discovery

Qumran, 1946/7

- three Bedouin shepherds in their teens were near an opening on side of cliff
- heard a noise of breaking when one teenager threw a **1** . .....
- teenagers went into the **2** . ..... and found a number of containers made of **3** . .....

The scrolls

- date from between 150 BCE and 70 CE
- thought to have been written by group of people known as the **4** . .....
- written mainly in the **5** . ..... language
- most are on religious topics, written using ink on parchment or papyrus

Questions 6–13

Do the following statements agree with the information given in Reading Passage 1?

In boxes 6–13 on your answer sheet, write

TRUE	*if the statement agrees with the information*
FALSE	*if the statement contradicts the information*
NOT GIVEN	*if there is no information on this*

6 The Bedouin teenagers who found the scrolls were disappointed by how little money they received for them.

7 There is agreement among academics about the origin of the Dead Sea Scrolls.

8 Most of the books of the Bible written on the scrolls are incomplete.

9 The information on the Copper Scroll is written in an unusual way.

10 Mar Samuel was given some of the scrolls as a gift.

11 In the early 1950s, a number of educational establishments in the US were keen to buy scrolls from Mar Samuel.

12 The scroll that was pieced together in 2017 contains information about annual occasions in the Qumran area 2,000 years ago.

13 Academics at the University of Haifa are currently researching how to decipher the final scroll.

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READING PASSAGE 2

*You should spend about 20 minutes on **Questions 14–26**, which are based on Reading Passage 2 below.*

A second attempt at domesticating the tomato

A It took at least 3,000 years for humans to learn how to domesticate the wild tomato and cultivate it for food. Now two separate teams in Brazil and China have done it all over again in less than three years. And they have done it better in some ways, as the re-domesticated tomatoes are more nutritious than the ones we eat at present.

This approach relies on the revolutionary CRISPR genome editing technique, in which changes are deliberately made to the DNA of a living cell, allowing genetic material to be added, removed or altered. The technique could not only improve existing crops, but could also be used to turn thousands of wild plants into useful and appealing foods. In fact, a third team in the US has already begun to do this with a relative of the tomato called the groundcherry.

This fast-track domestication could help make the world's food supply healthier and far more resistant to diseases, such as the rust fungus devastating wheat crops.

'This could transform what we eat,' says Jorg Kudla at the University of Munster in Germany, a member of the Brazilian team. 'There are 50,000 edible plants in the world, but 90 percent of our energy comes from just 15 crops.'

'We can now mimic the known domestication course of major crops like rice, maize, sorghum or others,' says Caixia Gao of the Chinese Academy of Sciences in Beijing. 'Then we might try to domesticate plants that have never been domesticated.'

B Wild tomatoes, which are native to the Andes region in South America, produce pea-sized fruits. Over many generations, peoples such as the Aztecs and Incas transformed the plant by selecting and breeding plants with mutations* in their genetic structure, which resulted in desirable traits such as larger fruit.

But every time a single plant with a mutation is taken from a larger population for breeding, much genetic diversity is lost. And sometimes the desirable mutations come with less desirable traits. For instance, the tomato strains grown for supermarkets have lost much of their flavour.

By comparing the genomes of modern plants to those of their wild relatives, biologists have been working out what genetic changes occurred as plants were domesticated. The teams in Brazil and China have now used this knowledge to reintroduce these changes from scratch while maintaining or even enhancing the desirable traits of wild strains.

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* mutations: changes in an organism's genetic structure that can be passed down to later generations

C Kudla's team made six changes altogether. For instance, they tripled the size of fruit by editing a gene called FRUIT WEIGHT, and increased the number of tomatoes per truss by editing another called MULTIFLORA.

While the historical domestication of tomatoes reduced levels of the red pigment lycopene – thought to have potential health benefits – the team in Brazil managed to boost it instead. The wild tomato has twice as much lycopene as cultivated ones; the newly domesticated one has five times as much.

'They are quite tasty,' says Kudla. 'A little bit strong. And very aromatic.'

The team in China re-domesticated several strains of wild tomatoes with desirable traits lost in domesticated tomatoes. In this way they managed to create a strain resistant to a common disease called bacterial spot race, which can devastate yields. They also created another strain that is more salt tolerant – and has higher levels of vitamin C.

D Meanwhile, Joyce Van Eck at the Boyce Thompson Institute in New York state decided to use the same approach to domesticate the groundcherry or goldenberry (*Physalis pruinosa*) for the first time. This fruit looks similar to the closely related Cape gooseberry (*Physalis peruviana*).

Groundcherries are already sold to a limited extent in the US but they are hard to produce because the plant has a sprawling growth habit and the small fruits fall off the branches when ripe. Van Eck's team has edited the plants to increase fruit size, make their growth more compact and to stop fruits dropping. 'There's potential for this to be a commercial crop,' says Van Eck. But she adds that taking the work further would be expensive because of the need to pay for a licence for the CRISPR technology and get regulatory approval.

E This approach could boost the use of many obscure plants, says Jonathan Jones of the Sainsbury Lab in the UK. But it will be hard for new foods to grow so popular with farmers and consumers that they become new staple crops, he thinks.

The three teams already have their eye on other plants that could be 'catapulted into the mainstream', including foxtail, oat-grass and cowpea. By choosing wild plants that are drought or heat tolerant, says Gao, we could create crops that will thrive even as the planet warms.

But Kudla didn't want to reveal which species were in his team's sights, because CRISPR has made the process so easy. 'Any one with the right skills could go to their lab and do this.'

Questions 14–18

Reading Passage 2 has five sections, **A–E**.

Which section contains the following information?

*Write the correct letter, **A–E**, in boxes 14–18 on your answer sheet.*

NB *You may use any letter more than once.*

14 a reference to a type of tomato that can resist a dangerous infection

15 an explanation of how problems can arise from focusing only on a certain type of tomato plant.

16 a number of examples of plants that are not cultivated at present but could be useful as food sources

17 a comparison between the early domestication of the tomato and more recent research

18 a personal reaction to the flavour of a tomato that has been genetically edited

Questions 19–23

Look at the following statements (Questions 19–23) and the list of researchers below.

*Match each statement with the correct researcher, **A–D**.*

*Write the correct letter, **A–D**, in boxes 19–23 on your answer sheet.*

NB *You may use any letter more than once.*

19 Domestication of certain plants could allow them to adapt to future environmental challenges.

20 The idea of growing and eating unusual plants may not be accepted on a large scale.

21 It is not advisable for the future direction of certain research to be made public.

22 Present efforts to domesticate one wild fruit are limited by the costs involved.

23 Humans only make use of a small proportion of the plant food available on Earth.

List of Researchers

A Jorg Kudla
B Caixia Gao
C Joyce Van Eck
D Jonathan Jones

Questions 24–26

Complete the sentences below.

*Choose **ONE WORD ONLY** from the passage for each answer.*

Write your answers in boxes 24–26 on your answer sheet.

24 An undesirable trait such as loss of . ..... may be caused by a mutation in a tomato gene.

25 By modifying one gene in a tomato plant, researchers made the tomato three times its original . ...

26 A type of tomato which was not badly affected by . ..... , and was rich in vitamin C, was produced by a team of researchers in China.

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READING PASSAGE 3

*You should spend about 20 minutes on **Questions 27–40**, which are based on Reading Passage 3 below.*

Insight or evolution?

Two scientists consider the origins of discoveries and other innovative behavior

Scientific discovery is popularly believed to result from the sheer genius of such intellectual stars as naturalist Charles Darwin and theoretical physicist Albert Einstein. Our view of such unique contributions to science often disregards the person's prior experience and the efforts of their lesser-known predecessors. Conventional wisdom also places great weight on insight in promoting breakthrough scientific achievements, as if ideas spontaneously pop into someone's head – fully formed and functional.

There may be some limited truth to this view. However, we believe that it largely misrepresents the real nature of scientific discovery, as well as that of creativity and innovation in many other realms of human endeavor.

Setting aside such greats as Darwin and Einstein – whose monumental contributions are duly celebrated – we suggest that innovation is more a process of trial and error, where two steps forward may sometimes come with one step back, as well as one or more steps to the right or left. This evolutionary view of human innovation undermines the notion of creative genius and recognizes the cumulative nature of scientific progress.

Consider one unheralded scientist: John Nicholson, a mathematical physicist working in the 1910s who postulated the existence of 'proto-elements' in outer space. By combining different numbers of weights of these proto-elements' atoms, Nicholson could recover the weights of all the elements in the then-known periodic table. These successes are all the more noteworthy given the fact that Nicholson was wrong about the presence of proto-elements: they do not actually exist. Yet, amid his often fanciful theories and wild speculations, Nicholson also proposed a novel theory about the structure of atoms. Niels Bohr, the Nobel prize-winning father of modern atomic theory, jumped off from this interesting idea to conceive his now-famous model of the atom.

What are we to make of this story? One might simply conclude that science is a collective and cumulative enterprise. That may be true, but there may be a deeper insight to be gleaned. We propose that science is constantly evolving, much as species of animals do. In biological systems, organisms may display new characteristics that result from random genetic mutations. In the same way, random, arbitrary or accidental mutations of ideas may help pave the way for advances in science. If mutations prove beneficial, then the animal or the scientific theory will continue to thrive and perhaps reproduce.

Support for this evolutionary view of behavioral innovation comes from many domains. Consider one example of an influential innovation in US horseracing. The so-called 'acey-deucy' stirrup placement, in which the rider's foot in his left stirrup is placed as much as 25 centimeters lower than the right, is believed to confer important speed advantages when turning on oval tracks. It was developed by a relatively unknown jockey named Jackie Westrope. Had Westrope conducted methodical investigations or examined extensive film records in a shrewd plan to outrun his rivals? Had he foreseen the speed advantage that would be conferred by riding acey-deucy? No. He suffered a leg injury, which left him unable to fully bend his left knee. His modification just happened to coincide with enhanced left-hand turning performance. This led to the rapid and widespread adoption of riding acey-deucy by many riders, a racing style which continues in today's thoroughbred racing.

Plenty of other stories show that fresh advances can arise from error, misadventure, and also pure serendipity – a happy accident. For example, in the early 1970s, two employees of the company 3M each had a problem: Spencer Silver had a product – a glue which was only slightly sticky – and no use for it, while his colleague Art Fry was trying to figure out how to affix temporary bookmarks in his hymn book without damaging its pages. The solution to both these problems was the invention of the brilliantly simple yet phenomenally successful Post-It note. Such examples give lie to the claim that ingenious, designing minds are responsible for human creativity and invention. Far more banal and mechanical forces may be at work; forces that are fundamentally connected to the laws of science.

The notions of insight, creativity and genius are often invoked, but they remain vague and of doubtful scientific utility, especially when one considers the diverse and enduring contributions of individuals such as Plato, Leonardo da Vinci, Shakespeare, Beethoven, Galileo, Newton, Kepler, Curie, Pasteur and Edison. These notions merely label rather than explain the evolution of human innovations. We need another approach, and there is a promising candidate.

The Law of Effect was advanced by psychologist Edward Thorndike in 1898, some 40 years after Charles Darwin published his groundbreaking work on biological evolution, *On the Origin of Species*. This simple law holds that organisms tend to repeat successful behaviors and to refrain from performing unsuccessful ones. Just like Darwin's Law of Natural Selection, the Law of Effect involves an entirely mechanical process of variation and selection, without any end objective in sight.

Of course, the origin of human innovation demands much further study. In particular, the provenance of the raw material on which the Law of Effect operates is not as clearly known as that of the genetic mutations on which the Law of Natural Selection operates. The generation of novel ideas and behaviors may not be entirely random, but constrained by prior successes and failures – of the current individual (such as Bohr) or of predecessors (such as Nicholson).

The time seems right for abandoning the naive notions of intelligent design and genius, and for scientifically exploring the true origins of creative behavior.

Questions 27–31

Choose the correct letter, ***A****,* ***B****,* ***C*** *or* ***D****.*

Write the correct letter in boxes 27–31 on your answer sheet.

27 The purpose of the first paragraph is to

A defend particular ideas.
B compare certain beliefs.
C disprove a widely held view.
D outline a common assumption.

28 What are the writers doing in the second paragraph?

A criticising an opinion
B justifying a standpoint
C explaining an approach
D supporting an argument

29 In the third paragraph, what do the writers suggest about Darwin and Einstein?

A They represent an exception to a general rule.
B Their way of working has been misunderstood.
C They are an ideal which others should aspire to.
D Their achievements deserve greater recognition.

30 John Nicholson is an example of a person whose idea

A established his reputation as an influential scientist.
B was only fully understood at a later point in history.
C laid the foundations for someone else's breakthrough.
D initially met with scepticism from the scientific community.

31 What is the key point of interest about the 'acey-deucy' stirrup placement?

A the simple reason why it was invented
B the enthusiasm with which it was adopted
C the research that went into its development
D the cleverness of the person who first used it

Questions 32–36

Do the following statements agree with the claims of the writer in Reading Passage 3?

In boxes 32–36 on your answer sheet, write

YES	*if the statement agrees with the claims of the writer*
NO	*if the statement contradicts the claims of the writer*
NOT GIVEN	*if it is impossible to say what the writer thinks about this*

32 Acknowledging people such as Plato or da Vinci as geniuses will help us understand the process by which great minds create new ideas.

33 The Law of Effect was discovered at a time when psychologists were seeking a scientific reason why creativity occurs.

34 The Law of Effect states that no planning is involved in the behaviour of organisms.

35 The Law of Effect sets out clear explanations about the sources of new ideas and behaviours.

36 Many scientists are now turning away from the notion of intelligent design and genius.

Questions 37–40

*Complete the summary using the list of words, **A–G**, below.*

*Write the correct letter, **A–G**, in boxes 37–40 on your answer sheet.*

The origins of creative behaviour

The traditional view of scientific discovery is that breakthroughs happen when a single great mind has sudden **37** ..... . Although this can occur, it is not often the case. Advances are more likely to be the result of a longer process. In some cases, this process involves **38** ..... , such as Nicholson's theory about proto-elements. In others, simple necessity may provoke innovation, as with Westrope's decision to modify the position of his riding stirrups. There is also often an element of **39** ..... , for example, the coincidence of ideas that led to the invention of the Post-It note. With both the Law of Natural Selection and the Law of Effect, there may be no clear **40** ..... involved, but merely a process of variation and selection.

A	invention	**B**	goals	**C**	compromise
D	mistakes	**E**	luck	**F**	inspiration
G	experiments				

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READING

READING PASSAGE 1

*You should spend about 20 minutes on **Questions 1–13**, which are based on Reading Passage 1 below.*

The thylacine

The extinct thylacine, also known as the Tasmanian tiger, was a marsupial* that bore a superficial resemblance to a dog. Its most distinguishing feature was the 13–19 dark brown stripes over its back, beginning at the rear of the body and extending onto the tail. The thylacine's average nose-to-tail length for adult males was 162.6 cm, compared to 153.7 cm for females.

The thylacine appeared to occupy most types of terrain except dense rainforest, with open eucalyptus forest thought to be its prime habitat. In terms of feeding, it was exclusively carnivorous, and its stomach was muscular with an ability to distend so that it could eat large amounts of food at one time, probably an adaptation to compensate for long periods when hunting was unsuccessful and food scarce. The thylacine was not a fast runner and probably caught its prey by exhausting it during a long pursuit. During long-distance chases, thylacines were likely to have relied more on scent than any other sense. They emerged to hunt during the evening, night and early morning and tended to retreat to the hills and forest for shelter during the day. Despite the common name 'tiger', the thylacine had a shy, nervous temperament. Although mainly nocturnal, it was sighted moving during the day and some individuals were even recorded basking in the sun.

The thylacine had an extended breeding season from winter to spring, with indications that some breeding took place throughout the year. The thylacine, like all marsupials, was tiny and hairless when born. Newborns crawled into the pouch on the belly of their mother, and attached themselves to one of the four teats, remaining there for up to three months. When old enough to leave the pouch, the young stayed in a lair such as a deep rocky cave, well-hidden nest or hollow log, whilst the mother hunted.

Approximately 4,000 years ago, the thylacine was widespread throughout New Guinea and most of mainland Australia, as well as the island of Tasmania. The most recent, well-dated occurrence of a thylacine on the mainland is a carbon-dated fossil from Murray Cave in Western Australia, which is around 3,100 years old. Its extinction coincided closely with the arrival of wild dogs called dingoes in Australia and a similar predator in New Guinea. Dingoes never reached Tasmania, and most scientists see this as the main reason for the thylacine's survival there.

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* marsupial: a mammal, such as a kangaroo, whose young are born incompletely developed and are typically carried and suckled in a pouch on the mother's belly

The dramatic decline of the thylacine in Tasmania, which began in the 1830s and continued for a century, is generally attributed to the relentless efforts of sheep farmers and bounty hunters** with shotguns. While this determined campaign undoubtedly played a large part, it is likely that various other factors also contributed to the decline and eventual extinction of the species. These include competition with wild dogs introduced by European settlers, loss of habitat along with the disappearance of prey species, and a distemper-like disease which may also have affected the thylacine.

There was only one successful attempt to breed a thylacine in captivity, at Melbourne Zoo in 1899. This was despite the large numbers that went through some zoos, particularly London Zoo and Tasmania's Hobart Zoo. The famous naturalist John Gould foresaw the thylacine's demise when he published his *Mammals of Australia* between 1848 and 1863, writing, 'The numbers of this singular animal will speedily diminish, extermination will have its full sway, and it will then, like the wolf of England and Scotland, be recorded as an animal of the past.'

However, there seems to have been little public pressure to preserve the thylacine, nor was much concern expressed by scientists at the decline of this species in the decades that followed. A notable exception was T.T. Flynn, Professor of Biology at the University of Tasmania. In 1914, he was sufficiently concerned about the scarcity of the thylacine to suggest that some should be captured and placed on a small island. But it was not until 1929, with the species on the very edge of extinction, that Tasmania's Animals and Birds Protection Board passed a motion protecting thylacines only for the month of December, which was thought to be their prime breeding season. The last known wild thylacine to be killed was shot by a farmer in the north-east of Tasmania in 1930, leaving just captive specimens. Official protection of the species by the Tasmanian government was introduced in July 1936, 59 days before the last known individual died in Hobart Zoo on 7th September, 1936.

There have been numerous expeditions and searches for the thylacine over the years, none of which has produced definitive evidence that thylacines still exist. The species was declared extinct by the Tasmanian government in 1986.

** bounty hunters: people who are paid a reward for killing a wild animal

Questions 1–5

Complete the notes below.

*Choose **ONE WORD ONLY** from the passage for each answer.*

Write your answers in boxes 1–5 on your answer sheet.

The thylacine

Appearance and behaviour

- looked rather like a dog
- had a series of stripes along its body and tail
- ate an entirely **1** . ..... diet
- probably depended mainly on **2** . ..... when hunting
- young spent first months of life inside its mother's **3** . .....

Decline and extinction

- last evidence in mainland Australia is a 3,100-year-old **4** . .....
- probably went extinct in mainland Australia due to animals known as dingoes
- reduction in **5** . ..... and available sources of food were partly responsible for decline in Tasmania

Questions 6–13

Do the following statements agree with the information given in Reading Passage 1?

In boxes 6–13 on your answer sheet, write

TRUE	*if the statement agrees with the information*
FALSE	*if the statement contradicts the information*
NOT GIVEN	*if there is no information on this*

6 Significant numbers of thylacines were killed by humans from the 1830s onwards.

7 Several thylacines were born in zoos during the late 1800s.

8 John Gould's prediction about the thylacine surprised some biologists.

9 In the early 1900s, many scientists became worried about the possible extinction of the thylacine.

10 T. T. Flynn's proposal to rehome captive thylacines on an island proved to be impractical.

11 There were still reasonable numbers of thylacines in existence when a piece of legislation protecting the species during their breeding season was passed.

12 From 1930 to 1936, the only known living thylacines were all in captivity.

13 Attempts to find living thylacines are now rarely made.

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READING PASSAGE 2

*You should spend about 20 minutes on **Questions 14–26**, which are based on Reading Passage 2 below.*

Palm oil

A Palm oil is an edible oil derived from the fruit of the African oil palm tree, and is currently the most consumed vegetable oil in the world. It's almost certainly in the soap we wash with in the morning, the sandwich we have for lunch, and the biscuits we snack on during the day. Why is palm oil so attractive for manufacturers? Primarily because its unique properties – such as remaining solid at room temperature – make it an ideal ingredient for long-term preservation, allowing many packaged foods on supermarket shelves to have 'best before' dates of months, even years, into the future.

B Many farmers have seized the opportunity to maximise the planting of oil palm trees. Between 1990 and 2012, the global land area devoted to growing oil palm trees grew from 6 to 17 million hectares, now accounting for around ten percent of total cropland in the entire world. From a mere two million tonnes of palm oil being produced annually globally 50 years ago, there are now around 60 million tonnes produced every single year, a figure looking likely to double or even triple by the middle of the century.

C However, there are multiple reasons why conservationists cite the rapid spread of oil palm plantations as a major concern. There are countless news stories of deforestation, habitat destruction and dwindling species populations, all as a direct result of land clearing to establish oil palm tree monoculture on an industrial scale, particularly in Malaysia and Indonesia. Endangered species – most famously the Sumatran orangutan, but also rhinos, elephants, tigers, and numerous other fauna – have suffered from the unstoppable spread of oil palm plantations.

D 'Palm oil is surely one of the greatest threats to global biodiversity,' declares Dr Farnon Ellwood of the University of the West of England, Bristol. 'Palm oil is replacing rainforest, and rainforest is where all the species are. That's a problem.' This has led to some radical questions among environmentalists, such as whether consumers should try to boycott palm oil entirely.

Meanwhile Bhavani Shankar, Professor at London's School of Oriental and African Studies, argues, 'It's easy to say that palm oil is the enemy and we should be against it. It makes for a more dramatic story, and it's very intuitive. But given the complexity of the argument, I think a much more nuanced story is closer to the truth.'

E One response to the boycott movement has been the argument for the vital role palm oil plays in lifting many millions of people in the developing world out of poverty. Is it desirable to have palm oil boycotted, replaced, eliminated from the global supply chain, given how many low-income people in developing countries depend on it for their livelihoods? How best to strike a utilitarian balance between these competing factors has become a serious bone of contention.

F Even the deforestation argument isn't as straightforward as it seems. Oil palm plantations produce at least four and potentially up to ten times more oil per hectare than soybean, rapeseed, sunflower or other competing oils. That immensely high yield – which is predominantly what makes it so profitable – is potentially also an ecological benefit. If ten times more palm oil can be produced from a patch of land than any competing oil, then ten times more land would need to be cleared in order to produce the same volume of oil from that competitor.

As for the question of carbon emissions, the issue really depends on what oil palm trees are replacing. Crops vary in the degree to which they sequester carbon – in other words, the amount of carbon they capture from the atmosphere and store within the plant. The more carbon a plant sequesters, the more it reduces the effect of climate change. As Shankar explains: '[Palm oil production] actually sequesters more carbon in some ways than other alternatives. […] Of course, if you're cutting down virgin forest it's terrible – that's what's happening in Indonesia and Malaysia, it's been allowed to get out of hand. But if it's replacing rice, for example, it might actually sequester more carbon.'

G The industry is now regulated by a group called the Roundtable on Sustainable Palm Oil (RSPO), consisting of palm growers, retailers, product manufacturers, and other interested parties. Over the past decade or so, an agreement has gradually been reached regarding standards that producers of palm oil have to meet in order for their product to be regarded as officially 'sustainable'. The RSPO insists upon no virgin forest clearing, transparency and regular assessment of carbon stocks, among other criteria. Only once these requirements are fully satisfied is the oil allowed to be sold as certified sustainable palm oil (CSPO). Recent figures show that the RSPO now certifies around 12 million tonnes of palm oil annually, equivalent to roughly 21 percent of the world's total palm oil production.

H There is even hope that oil palm plantations might not need to be such sterile monocultures, or 'green deserts', as Ellwood describes them. New research at Ellwood's lab hints at one plant which might make all the difference. The bird's nest fern *(Asplenium nidus)* grows on trees in an epiphytic fashion (meaning it's dependent on the tree only for support, not for nutrients), and is native to many tropical regions, where as a keystone species it performs a vital ecological role. Ellwood believes that reintroducing the bird's nest fern into oil palm plantations could potentially allow these areas to recover their biodiversity, providing a home for all manner of species, from fungi and bacteria, to invertebrates such as insects, amphibians, reptiles and even mammals.

Questions 14–20

Reading Passage 2 has eight sections, **A–H**.

Which section contains the following information?

*Write the correct letter, **A–H**, in boxes 14–20 on your answer sheet.*

14 examples of a range of potential environmental advantages of oil palm tree cultivation

15 description of an organisation which controls the environmental impact of palm oil production

16 examples of the widespread global use of palm oil

17 reference to a particular species which could benefit the ecosystem of oil palm plantations

18 figures illustrating the rapid expansion of the palm oil industry

19 an economic justification for not opposing the palm oil industry

20 examples of creatures badly affected by the establishment of oil palm plantations

Questions 21 and 22

*Choose **TWO** letters, **A–E**.*

Write the correct letters in boxes 21 and 22 on your answer sheet.

Which **TWO** statements are made about the Roundtable on Sustainable Palm Oil (RSPO)?

A Its membership has grown steadily over the course of the last decade.
B It demands that certified producers be open and honest about their practices.
C It took several years to establish its set of criteria for sustainable palm oil certification.
D Its regulations regarding sustainability are stricter than those governing other industries.
E It was formed at the request of environmentalists concerned about the loss of virgin forests.

Questions 23–26

Complete the sentences below.

*Choose **NO MORE THAN TWO WORDS** from the passage for each answer.*

Write your answers in boxes 23–26 on your answer sheet.

23 One advantage of palm oil for manufacturers is that it stays . ..... even when not refrigerated.

24 The . ..... is the best known of the animals suffering habitat loss as a result of the spread of oil palm plantations.

25 As one of its criteria for the certification of sustainable palm oil, the RSPO insists that growers check . ..... on a routine basis.

26 Ellwood and his researchers are looking into whether the bird's nest fern could restore . ..... in areas where oil palm trees are grown.

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READING PASSAGE 3

*You should spend about 20 minutes on **Questions 27–40**, which are based on Reading Passage 3 below.*

Building the Skyline: The Birth and Growth of Manhattan's Skyscrapers

Katharine L. Shester reviews a book by Jason Barr about the development of New York City

In *Building the Skyline*, Jason Barr takes the reader through a detailed history of New York City. The book combines geology, history, economics, and a lot of data to explain why business clusters developed where they did and how the early decisions of workers and firms shaped the skyline we see today. *Building the Skyline* is organized into two distinct parts. The first is primarily historical and addresses New York's settlement and growth from 1609 to 1900; the second deals primarily with the 20th century and is a compilation of chapters commenting on different aspects of New York's urban development. The tone and organization of the book changes somewhat between the first and second parts, as the latter chapters incorporate aspects of Barr's related research papers.

Barr begins chapter one by taking the reader on a 'helicopter time-machine' ride – giving a fascinating account of how the New York landscape in 1609 might have looked from the sky. He then moves on to a subterranean walking tour of the city, indicating the location of rock and water below the subsoil, before taking the reader back to the surface. His love of the city comes through as he describes various fun facts about the location of the New York residence of early 19th-century vice-president Aaron Burr as well as a number of legends about the city.

Chapters two and three take the reader up to the Civil War (1861–1865), with chapter two focusing on the early development of land and the implementation of a grid system in 1811. Chapter three focuses on land use before the Civil War. Both chapters are informative and well researched and set the stage for the economic analysis that comes later in the book. I would have liked Barr to expand upon his claim that existing tenements* prevented skyscrapers in certain neighborhoods because 'likely no skyscraper developer was interested in performing the necessary "slum clearance"'. Later in the book, Barr makes the claim that the depth of bedrock** was not a limiting factor for developers, as foundation costs were a small fraction of the cost of development. At first glance, it is not obvious why slum clearance would be limiting, while more expensive foundations would not.

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* a tenement: a multi-occupancy building of any sort, but particularly a run-down apartment building or slum building

** bedrock: the solid, hard rock in the ground that lies under a loose layer of soil

Chapter four focuses on immigration and the location of neighborhoods and tenements in the late 19th century. Barr identifies four primary immigrant enclaves and analyzes their locations in terms of the amenities available in the area. Most of these enclaves were located on the least valuable land, between the industries located on the waterfront and the wealthy neighborhoods bordering Central Park.

Part two of the book begins with a discussion of the economics of skyscraper height. In chapter five, Barr distinguishes between engineering height, economic height, and developer height — where engineering height is the tallest building that can be safely made at a given time, economic height is the height that is most efficient from society's point of view, and developer height is the actual height chosen by the developer, who is attempting to maximize return on investment.

Chapter five also has an interesting discussion of the technological advances that led to the construction of skyscrapers. For example, the introduction of iron and steel skeletal frames made thick, load-bearing walls unnecessary, expanding the usable square footage of buildings and increasing the use of windows and availability of natural light. Chapter six then presents data on building height throughout the 20th century and uses regression analysis to 'predict' building construction. While less technical than the research paper on which the chapter is based, it is probably more technical than would be preferred by a general audience.

Chapter seven tackles the 'bedrock myth', the assumption that the absence of bedrock close to the surface between Downtown and Midtown New York is the reason for skyscrapers not being built between the two urban centers. Rather, Barr argues that while deeper bedrock does increase foundation costs, these costs were neither prohibitively high nor were they large compared to the overall cost of building a skyscraper. What I enjoyed the most about this chapter was Barr's discussion of how foundations are actually built. He describes the use of caissons, which enable workers to dig down for considerable distances, often below the water table, until they reach bedrock. Barr's thorough technological history discusses not only how caissons work, but also the dangers involved. While this chapter references empirical research papers, it is a relatively easy read.

Chapters eight and nine focus on the birth of Midtown and the building boom of the 1920s. Chapter eight contains lengthy discussions of urban economic theory that may serve as a distraction to readers primarily interested in New York. However, they would be well-suited for undergraduates learning about the economics of cities. In the next chapter, Barr considers two of the primary explanations for the building boom of the 1920s — the first being exuberance, and the second being financing. He uses data to assess the viability of these two explanations and finds that supply and demand factors explain much of the development of the 1920s; though it enabled the boom, cheap credit was not, he argues, the primary cause.

In the final chapter (chapter 10), Barr discusses another of his empirical papers that estimates Manhattan land values from the mid-19th century to the present day. The data work that went into these estimations is particularly impressive. Toward the end of the chapter, Barr assesses 'whether skyscrapers are a cause or an effect of high land values'. He finds that changes in land values predict future building height, but the reverse is not true. The book ends with an epilogue, in which Barr discusses the impact of climate change on the city and makes policy suggestions for New York going forward.

Questions 27–31

Choose the correct letter, ***A****,* ***B****,* ***C*** *or* ***D****.*

Write the correct letter in boxes 27–31 on your answer sheet.

27 What point does Shester make about Barr's book in the first paragraph?

A It gives a highly original explanation for urban development.
B Elements of Barr's research papers are incorporated throughout the book.
C Other books that are available on the subject have taken a different approach.
D It covers a range of factors that affected the development of New York.

28 How does Shester respond to the information in the book about tenements?

A She describes the reasons for Barr's interest.
B She indicates a potential problem with Barr's analysis.
C She compares Barr's conclusion with that of other writers.
D She provides details about the sources Barr used for his research.

29 What does Shester say about chapter six of the book?

A It contains conflicting data.
B It focuses too much on possible trends.
C It is too specialised for most readers.
D It draws on research that is out of date.

30 What does Shester suggest about the chapters focusing on the 1920s building boom?

A The information should have been organised differently.
B More facts are needed about the way construction was financed.
C The explanation that is given for the building boom is unlikely.
D Some parts will have limited appeal to certain people.

31 What impresses Shester the most about the chapter on land values?

A the broad time period that is covered
B the interesting questions that Barr asks
C the nature of the research into the topic
D the recommendations Barr makes for the future

Questions 32–35

Do the following statements agree with the claims of the writer in Reading Passage 3?

In boxes 32–35 on your answer sheet, write

YES	*if the statement agrees with the claims of the writer*
NO	*if the statement contradicts the claims of the writer*
NOT GIVEN	*if it is impossible to say what the writer thinks about this*

32 The description in the first chapter of how New York probably looked from the air in the early 1600s lacks interest.

33 Chapters two and three prepare the reader well for material yet to come.

34 The biggest problem for many nineteenth-century New York immigrant neighbourhoods was a lack of amenities.

35 In the nineteenth century, New York's immigrant neighbourhoods tended to concentrate around the harbour.

Questions 36–40

Complete the summary using the list of phrases, ***A–J****, below.*

Write the correct letter, ***A–J****, in boxes 36–40 on your answer sheet.*

The bedrock myth

In chapter seven, Barr indicates how the lack of bedrock close to the surface does not explain why skyscrapers are absent from **36** ..... . He points out that although the cost of foundations increases when bedrock is deep below the surface, this cannot be regarded as **37** ....., especially when compared to **38** ..... .

A particularly enjoyable part of the chapter was Barr's account of how foundations are built. He describes not only how **39** ..... are made possible by the use of caissons, but he also discusses their **40** ..... . The chapter is well researched but relatively easy to understand.

A	development plans	**B**	deep excavations	**C**	great distance
D	excessive expense	**E**	impossible tasks	**F**	associated risks
G	water level	**H**	specific areas	**I**	total expenditure
J	construction guidelines				

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READING

READING PASSAGE 1

*You should spend about 20 minutes on **Questions 1–13**, which are based on Reading Passage 1 below.*

Bats to the rescue

How Madagascar's bats are helping to save the rainforest

There are few places in the world where relations between agriculture and conservation are more strained. Madagascar's forests are being converted to agricultural land at a rate of one percent every year. Much of this destruction is fuelled by the cultivation of the country's main staple crop: rice. And a key reason for this destruction is that insect pests are destroying vast quantities of what is grown by local subsistence farmers, leading them to clear forest to create new paddy fields. The result is devastating habitat and biodiversity loss on the island, but not all species are suffering. In fact, some of the island's insectivorous bats are currently thriving and this has important implications for farmers and conservationists alike.

Enter University of Cambridge zoologist Ricardo Rocha. He's passionate about conservation, and bats. More specifically, he's interested in how bats are responding to human activity and deforestation in particular. Rocha's new study shows that several species of bats are giving Madagascar's rice farmers a vital pest control service by feasting on plagues of insects. And this, he believes, can ease the financial pressure on farmers to turn forest into fields.

Bats comprise roughly one-fifth of all mammal species in Madagascar and thirty-six recorded bat species are native to the island, making it one of the most important regions for conservation of this animal group anywhere in the world.

Co-leading an international team of scientists, Rocha found that several species of indigenous bats are taking advantage of habitat modification to hunt insects swarming above the country's rice fields. They include the Malagasy mouse-eared bat, Major's long-fingered bat, the Malagasy white-bellied free-tailed bat and Peters' wrinkle-lipped bat.

'These winner species are providing a valuable free service to Madagascar as biological pest suppressors,' says Rocha. 'We found that six species of bat are preying on rice pests, including the paddy swarming caterpillar and grass webworm. The damage which these insects cause puts the island's farmers under huge financial pressure and that encourages deforestation.'

The study, now published in the journal *Agriculture, Ecosystems and Environment,* set out to investigate the feeding activity of insectivorous bats in the farmland bordering the Ranomafana National Park in the southeast of the country.

Rocha and his team used state-of-the-art ultrasonic recorders to record over a thousand bat 'feeding buzzes' (echolocation sequences used by bats to target their prey) at 54 sites, in order to identify the favourite feeding spots of the bats. They next used DNA barcoding techniques to analyse droppings collected from bats at the different sites.

The recordings revealed that bat activity over rice fields was much higher than it was in continuous forest – seven times higher over rice fields which were on flat ground, and sixteen times higher over fields on the sides of hills – leaving no doubt that the animals are preferentially foraging in these man-made ecosystems. The researchers suggest that the bats favour these fields because lack of water and nutrient run-off make these crops more susceptible to insect pest infestations. DNA analysis showed that all six species of bat had fed on economically important insect pests. While the findings indicated that rice farming benefits most from the bats, the scientists also found indications that the bats were consuming pests of other crops, including the black twig borer (which infests coffee plants), the sugarcane cicada, the macadamia nut-borer, and the sober tabby (a pest of citrus fruits).

'The effectiveness of bats as pest controllers has already been proven in the USA and Catalonia,' said co-author James Kemp, from the University of Lisbon. 'But our study is the first to show this happening in Madagascar, where the stakes for both farmers and conservationists are so high.'

Local people may have a further reason to be grateful to their bats. While the animal is often associated with spreading disease, Rocha and his team found evidence that Malagasy bats feed not just on crop pests but also on mosquitoes – carriers of malaria, Rift Valley fever virus and elephantiasis – as well as blackflies, which spread river blindness.

Rocha points out that the relationship is complicated. When food is scarce, bats become a crucial source of protein for local people. Even the children will hunt them. And as well as roosting in trees, the bats sometimes roost in buildings, but are not welcomed there because they make them unclean. At the same time, however, they are associated with sacred caves and the ancestors, so they can be viewed as beings between worlds, which makes them very significant in the culture of the people. And one potential problem is that while these bats are benefiting from farming, at the same time deforestation is reducing the places where they can roost, which could have long-term effects on their numbers. Rocha says, 'With the right help, we hope that farmers can promote this mutually beneficial relationship by installing bat houses.'

Rocha and his colleagues believe that maximising bat populations can help to boost crop yields and promote sustainable livelihoods. The team is now calling for further research to quantify this contribution. 'I'm very optimistic,' says Rocha. 'If we give nature a hand, we can speed up the process of regeneration.'

Questions 1–6

Do the following statements agree with the information given in Reading Passage 1?

In boxes 1–6 on your answer sheet, write

TRUE	*if the statement agrees with the information*
FALSE	*if the statement contradicts the information*
NOT GIVEN	*if there is no information on this*

1 Many Madagascan forests are being destroyed by attacks from insects.

2 Loss of habitat has badly affected insectivorous bats in Madagascar.

3 Ricardo Rocha has carried out studies of bats in different parts of the world.

4 Habitat modification has resulted in indigenous bats in Madagascar becoming useful to farmers.

5 The Malagasy mouse-eared bat is more common than other indigenous bat species in Madagascar.

6 Bats may feed on paddy swarming caterpillars and grass webworms.

Questions 7–13

Complete the table below.

*Choose **ONE WORD ONLY** from the passage for each answer.*

Write your answers in boxes 7–13 on your answer sheet.

The study carried out by Rocha's team	
Aim	• to investigate the feeding habits of bats in farmland near the Ranomafana National Park
Method	• ultrasonic recording to identify favourite feeding spots • DNA analysis of bat **7** . .....
Findings	• the bats – were most active in rice fields located on hills – ate pests of rice, **8** . ..... , sugarcane, nuts and fruit – prevent the spread of disease by eating **9** . ..... and blackflies • local attitudes to bats are mixed: – they provide food rich in **10** . ..... – the buildings where they roost become **11** . ..... – they play an important role in local **12** . .....
Recommendation	• farmers should provide special **13** . ..... to support the bat population

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READING PASSAGE 2

*You should spend about 20 minutes on **Questions 14–26**, which are based on Reading Passage 2 below.*

Does education fuel economic growth?

A Over the last decade, a huge database about the lives of southwest German villagers between 1600 and 1900 has been compiled by a team led by Professor Sheilagh Ogilvie at Cambridge University's Faculty of Economics. It includes court records, guild ledgers, parish registers, village censuses, tax lists and – the most recent addition – 9,000 handwritten inventories listing over a million personal possessions belonging to ordinary women and men across three centuries. Ogilvie, who discovered the inventories in the archives of two German communities 30 years ago, believes they may hold the answer to a conundrum that has long puzzled economists: the lack of evidence for a causal link between education and a country's economic growth.

B As Ogilvie explains, 'Education helps us to work more productively, invent better technology, and earn more … surely it must be critical for economic growth? But, if you look back through history, there's no evidence that having a high literacy rate made a country industrialise earlier.' Between 1600 and 1900, England had only mediocre literacy rates by European standards, yet its economy grew fast and it was the first country to industrialise. During this period, Germany and Scandinavia had excellent literacy rates, but their economies grew slowly and they industrialised late. 'Modern cross-country analyses have also struggled to find evidence that education causes economic growth, even though there is plenty of evidence that growth increases education,' she adds.

C In the handwritten inventories that Ogilvie is analysing are the belongings of women and men at marriage, remarriage and death. From badger skins to Bibles, sewing machines to scarlet bodices – the villagers' entire worldly goods are included. Inventories of agricultural equipment and craft tools reveal economic activities; ownership of books and education-related objects like pens and slates suggests how people learned. In addition, the tax lists included in the database record the value of farms, workshops, assets and debts; signatures and people's estimates of their age indicate literacy and numeracy levels; and court records reveal obstacles (such as the activities of the guilds*) that stifled industry.

Previous studies usually had just one way of linking education with economic growth – the presence of schools and printing presses, perhaps, or school enrolment, or the ability to sign names. According to Ogilvie, the database provides multiple indicators for the same individuals, making it possible to analyse links between literacy, numeracy, wealth, and industriousness, for individual women and men over the long term.

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* guild: an association of artisans or merchants which oversees the practice of their craft or trade in a particular area

D Ogilvie and her team have been building the vast database of material possessions on top of their full demographic reconstruction of the people who lived in these two German communities. 'We can follow the same people – and their descendants – across 300 years of educational and economic change,' she says. Individual lives have unfolded before their eyes. Stories like that of the 24-year-olds Ana Regina and Magdalena Riethmüllerin, who were chastised in 1707 for reading books in church instead of listening to the sermon. 'This tells us they were continuing to develop their reading skills at least a decade after leaving school,' explains Ogilvie. The database also reveals the case of Juliana Schweickherdt, a 50-year-old spinster living in the small Black Forest community of Wildberg, who was reprimanded in 1752 by the local weavers' guild for 'weaving cloth and combing wool, counter to the guild ordinance'. When Juliana continued taking jobs reserved for male guild members, she was summoned before the guild court and told to pay a fine equivalent to one third of a servant's annual wage. It was a small act of defiance by today's standards, but it reflects a time when laws in Germany and elsewhere regulated people's access to labour markets. The dominance of guilds not only prevented people from using their skills, but also held back even the simplest industrial innovation.

E The data-gathering phase of the project has been completed and now, according to Ogilvie, it is time 'to ask the big questions'. One way to look at whether education causes economic growth is to 'hold wealth constant'. This involves following the lives of different people with the same level of wealth over a period of time. If wealth is constant, it is possible to discover whether education was, for example, linked to the cultivation of new crops, or to the adoption of industrial innovations like sewing machines. The team will also ask what aspect of education helped people engage more with productive and innovative activities. Was it, for instance, literacy, numeracy, book ownership, years of schooling? Was there a threshold level – a tipping point – that needed to be reached to affect economic performance?

F Ogilvie hopes to start finding answers to these questions over the next few years. One thing is already clear, she says: the relationship between education and economic growth is far from straightforward. 'German-speaking central Europe is an excellent laboratory for testing theories of economic growth,' she explains. Between 1600 and 1900, literacy rates and book ownership were high and yet the region remained poor. It was also the case that local guilds and merchant associations were extremely powerful and legislated against anything that undermined their monopolies. In villages throughout the region, guilds blocked labour migration and resisted changes that might reduce their influence.

'Early findings suggest that the potential benefits of education for the economy can be held back by other barriers, and this has implications for today,' says Ogilvie. 'Huge amounts are spent improving education in developing countries, but this spending can fail to deliver economic growth if restrictions block people – especially women and the poor – from using their education in economically productive ways. If economic institutions are poorly set up, for instance, education can't lead to growth.'

Questions 14–18

Reading Passage 2 has six sections, **A–F**.

Which section contains the following information?

*Write the correct letter, **A–F**, in boxes 14–18 on your answer sheet.*

14 an explanation of the need for research to focus on individuals with a fairly consistent income

15 examples of the sources the database has been compiled from

16 an account of one individual's refusal to obey an order

17 a reference to a region being particularly suited to research into the link between education and economic growth

18 examples of the items included in a list of personal possessions

Questions 19–22

Complete the summary below.

*Choose **ONE WORD** from the passage for each answer.*

Write your answers in boxes 19–22 on your answer sheet.

Demographic reconstruction of two German communities

The database that Ogilvie and her team has compiled sheds light on the lives of a range of individuals, as well as those of their **19** ....., over a 300-year period. For example, Ana Regina and Magdalena Riethmüllerin were reprimanded for reading while they should have been paying attention to a **20** ...... There was also Juliana Schweickherdt, who came to the notice of the weavers' guild in the year 1752 for breaking guild rules. As a punishment, she was later given a **21** ...... Cases like this illustrate how the guilds could prevent **22** ..... and stop skilled people from working.

Questions 23 and 24

*Choose **TWO** letters, **A–E**.*

Write the correct letters in boxes 23 and 24 on your answer sheet.

Which **TWO** of the following statements does the writer make about literacy rates in Section B?

A Very little research has been done into the link between high literacy rates and improved earnings.
B Literacy rates in Germany between 1600 and 1900 were very good.
C There is strong evidence that high literacy rates in the modern world result in economic growth.
D England is a good example of how high literacy rates helped a country industrialise.
E Economic growth can help to improve literacy rates.

Questions 25 and 26

*Choose **TWO** letters, **A–E**.*

Write the correct letters in boxes 25 and 26 on your answer sheet.

Which **TWO** of the following statements does the writer make in Section F about guilds in German-speaking Central Europe between 1600 and 1900?

A They helped young people to learn a skill.
B They were opposed to people moving to an area for work.
C They kept better records than guilds in other parts of the world.
D They opposed practices that threatened their control over a trade.
E They predominantly consisted of wealthy merchants.

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READING PASSAGE 3

*You should spend about 20 minutes on **Questions 27–40**, which are based on Reading Passage 3 below.*

Timur Gareyev – blindfold chess champion

A Next month, a chess player named Timur Gareyev will take on nearly 50 opponents at once. But that is not the hard part. While his challengers will play the games as normal, Gareyev himself will be blindfolded. Even by world record standards, it sets a high bar for human performance. The 28-year-old already stands out in the rarefied world of blindfold chess. He has a fondness for bright clothes and unusual hairstyles, and he gets his kicks from the adventure sport of BASE jumping. He has already proved himself a strong chess player, too. In a 10-hour chess marathon in 2013, Gareyev played 33 games in his head simultaneously. He won 29 and lost none. The skill has become his brand: he calls himself the Blindfold King.

B But Gareyev's prowess has drawn interest from beyond the chess-playing community. In the hope of understanding how he and others like him can perform such mental feats, researchers at the University of California in Los Angeles (UCLA) called him in for tests. They now have their first results. 'The ability to play a game of chess with your eyes closed is not a far reach for most accomplished players,' said Jesse Rissman, who runs a memory lab at UCLA. 'But the thing that's so remarkable about Timur and a few other individuals is the number of games they can keep active at once. To me it is simply astonishing.'

C Gareyev learned to play chess in his native Uzbekistan when he was six years old. Tutored by his grandfather, he entered his first tournament aged eight and soon became obsessed with competitions. At 16, he was crowned Asia's youngest ever chess grandmaster. He moved to the US soon after, and as a student helped his university win its first national chess championship. In 2013, Gareyev was ranked the third best chess player in the US.

D To the uninitiated, blindfold chess seems to call for superhuman skill. But displays of the feat go back centuries. The first recorded game in Europe was played in 13th-century Florence. In 1947, the Argentinian grandmaster Miguel Najdorf played 45 simultaneous games in his mind, winning 39 in the 24-hour session.

E Accomplished players can develop the skill of playing blind even without realising it. The nature of the game is to run through possible moves in the mind to see how they play out. From this, regular players develop a memory for the patterns the pieces make, the defences and attacks. 'You recreate it in your mind,' said Gareyev. 'A lot of players are capable of doing what I'm doing.' The real mental challenge comes from playing multiple games at once in the head. Not only must the positions of each piece on every board be memorised, they must be recalled

faithfully when needed, updated with each player's moves, and then reliably stored again, so the brain can move on to the next board. First moves can be tough to remember because they are fairly uninteresting. But the ends of games are taxing too, as exhaustion sets in. When Gareyev is tired, his recall can get patchy. He sometimes makes moves based on only a fragmented memory of the pieces' positions.

F The scientists first had Gareyev perform some standard memory tests. These assessed his ability to hold numbers, pictures and words in mind. One classic test measures how many numbers a person can repeat, both forwards and backwards, soon after hearing them. Most people manage about seven. 'He was not exceptional on any of these standard tests,' said Rissman. 'We didn't find anything other than playing chess that he seems to be supremely gifted at.' But next came the brain scans. With Gareyev lying down in the machine, Rissman looked at how well connected the various regions of the chess player's brain were. Though the results are tentative and as yet unpublished, the scans found much greater than average communication between parts of Gareyev's brain that make up what is called the frontoparietal control network. Of 63 people scanned alongside the chess player, only one or two scored more highly on the measure. 'You use this network in almost any complex task. It helps you to allocate attention, keep rules in mind, and work out whether you should be responding or not,' said Rissman.

G It was not the only hint of something special in Gareyev's brain. The scans also suggest that Gareyev's visual network is more highly connected to other brain parts than usual. Initial results suggest that the areas of his brain that process visual images – such as chess boards – may have stronger links to other brain regions, and so be more powerful than normal. While the analyses are not finalised yet, they may hold the first clues to Gareyev's extraordinary ability.

H For the world record attempt, Gareyev hopes to play 47 blindfold games at once in about 16 hours. He will need to win 80% to claim the title. 'I don't worry too much about the winning percentage, that's never been an issue for me,' he said. 'The most important part of blindfold chess for me is that I have found the one thing that I can fully dedicate myself to. I miss having an obsession.'

Questions 27–32

Reading Passage 3 has eight paragraphs, **A–H**.

Which paragraph contains the following information?

*Write the correct letter, **A–H**, in boxes 27–32 on your answer sheet.*

NB *You may use any letter more than once.*

27 a reference to earlier examples of blindfold chess

28 an outline of what blindfold chess involves

29 a claim that Gareyev's skill is limited to chess

30 why Gareyev's skill is of interest to scientists

31 an outline of Gareyev's priorities

32 a reason why the last part of a game may be difficult

Questions 33–36

Do the following statements agree with the information given in Reading Passage 3?

In boxes 33–36 on your answer sheet, write

TRUE	*if the statement agrees with the information*
FALSE	*if the statement contradicts the information*
NOT GIVEN	*if there is no information about this*

33 In the forthcoming games, all the participants will be blindfolded.

34 Gareyev has won competitions in BASE jumping.

35 UCLA is the first university to carry out research into blindfold chess players.

36 Good chess players are likely to be able to play blindfold chess.

Questions 37–40

Complete the summary below.

*Choose **ONE WORD ONLY** from the passage for each answer.*

Write your answers in boxes 37–40 on your answer sheet.

How the research was carried out

The researchers started by testing Gareyev's **37** ..... ; for example, he was required to recall a string of **38** ..... in order and also in reverse order. Although his performance was normal, scans showed an unusual amount of **39** ..... within the areas of Gareyev's brain that are concerned with directing attention. In addition, the scans raised the possibility of unusual strength in the parts of his brain that deal with **40** ..... input.

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READING

READING PASSAGE 1

*You should spend about 20 minutes on **Questions 1–13,** which are based on Reading Passage 1 below.*

Why we need to protect polar bears

Polar bears are being increasingly threatened by the effects of climate change, but their disappearance could have far-reaching consequences. They are uniquely adapted to the extreme conditions of the Arctic Circle, where temperatures can reach −40°C. One reason for this is that they have up to 11 centimetres of fat underneath their skin. Humans with comparative levels of adipose tissue would be considered obese and would be likely to suffer from diabetes and heart disease. Yet the polar bear experiences no such consequences.

A 2014 study by Shi Ping Liu and colleagues sheds light on this mystery. They compared the genetic structure of polar bears with that of their closest relatives from a warmer climate, the brown bears. This allowed them to determine the genes that have allowed polar bears to survive in one of the toughest environments on Earth. Liu and his colleagues found the polar bears had a gene known as APoB, which reduces levels of low-density lipoproteins (LDLs) – a form of 'bad' cholesterol. In humans, mutations of this gene are associated with increased risk of heart disease. Polar bears may therefore be an important study model to understand heart disease in humans.

The genome of the polar bear may also provide the solution for another condition, one that particularly affects our older generation: osteoporosis. This is a disease where bones show reduced density, usually caused by insufficient exercise, reduced calcium intake or food starvation. Bone tissue is constantly being remodelled, meaning that bone is added or removed, depending on nutrient availability and the stress that the bone is under. Female polar bears, however, undergo extreme conditions during every pregnancy. Once autumn comes around, these females will dig maternity dens in the snow and will remain there throughout the winter, both before and after the birth of their cubs. This process results in about six months of fasting, where the female bears have to keep themselves and their cubs alive, depleting their own calcium and calorie reserves. Despite this, their bones remain strong and dense.

Physiologists Alanda Lennox and Allen Goodship found an explanation for this paradox in 2008. They discovered that pregnant bears were able to increase the density of their bones before they started to build their dens. In addition, six months later, when they finally emerged from the den with their cubs, there was no evidence of significant loss of bone density. Hibernating brown bears do not have this capacity and must therefore resort to major bone reformation in the following spring. If the mechanism of bone remodelling in polar bears can be understood, many bedridden humans, and even astronauts, could potentially benefit.

The medical benefits of the polar bear for humanity certainly have their importance in our conservation efforts, but these should not be the only factors taken into consideration. We tend to want to protect animals we think are intelligent and possess emotions, such as elephants and primates. Bears, on the other hand, seem to be perceived as stupid and in many cases violent. And yet anecdotal evidence from the field challenges those assumptions, suggesting for example that polar bears have good problem-solving abilities. A male bear called GoGo in Tennoji Zoo, Osaka, has even been observed making use of a tool to manipulate his environment. The bear used a tree branch on multiple occasions to dislodge a piece of meat hung out of his reach. Problem-solving ability has also been witnessed in wild polar bears, although not as obviously as with GoGo. A calculated move by a male bear involved running and jumping onto barrels in an attempt to get to a photographer standing on a platform four metres high.

In other studies, such as one by Alison Ames in 2008, polar bears showed deliberate and focussed manipulation. For example, Ames observed bears putting objects in piles and then knocking them over in what appeared to be a game. The study demonstrates that bears are capable of agile and thought-out behaviours. These examples suggest bears have greater creativity and problem-solving abilities than previously thought.

As for emotions, while the evidence is once again anecdotal, many bears have been seen to hit out at ice and snow – seemingly out of frustration – when they have just missed out on a kill. Moreover, polar bears can form unusual relationships with other species, including playing with the dogs used to pull sleds in the Arctic. Remarkably, one hand-raised polar bear called Agee has formed a close relationship with her owner Mark Dumas to the point where they even swim together. This is even more astonishing since polar bears are known to actively hunt humans in the wild.

If climate change were to lead to their extinction, this would mean not only the loss of potential breakthroughs in human medicine, but more importantly, the disappearance of an intelligent, majestic animal.

Questions 1–7

Do the following statements agree with the information given in Reading Passage 1?

In boxes 1–7 on your answer sheet, write

TRUE	*if the statement agrees with the information*
FALSE	*if the statement contradicts the information*
NOT GIVEN	*if there is no information on this*

1 Polar bears suffer from various health problems due to the build-up of fat under their skin.

2 The study done by Liu and his colleagues compared different groups of polar bears.

3 Liu and colleagues were the first researchers to compare polar bears and brown bears genetically.

4 Polar bears are able to control their levels of 'bad' cholesterol by genetic means.

5 Female polar bears are able to survive for about six months without food.

6 It was found that the bones of female polar bears were very weak when they came out of their dens in spring.

7 The polar bear's mechanism for increasing bone density could also be used by people one day.

Questions 8–13

Complete the table below.

*Choose **ONE WORD ONLY** from the passage for each answer.*

Write your answers in boxes 8–13 on your answer sheet.

Reasons why polar bears should be protected

People think of bears as unintelligent and **8** .....

However, this may not be correct. For example:

- In Tennoji Zoo, a bear has been seen using a branch as a **9** ..... This allowed him to knock down some **10** .....
- A wild polar bear worked out a method of reaching a platform where a **11** ..... was located.
- Polar bears have displayed behaviour such as conscious manipulation of objects and activity similar to a **12** .....

Bears may also display emotions. For example:

- They may make movements suggesting **13** ..... if disappointed when hunting.
- They may form relationships with other species.

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READING PASSAGE 2

*You should spend about 20 minutes on **Questions 14–26**, which are based on Reading Passage 2 on pages 21 and 22.*

Questions 14–20

Reading Passage 2 has seven paragraphs, **A–G**.

Choose the correct heading for each paragraph from the list of headings below.

*Write the correct number, **i–ix**, in boxes 14–20 on your answer sheet.*

List of Headings

i	The areas and artefacts within the pyramid itself
ii	A difficult task for those involved
iii	A king who saved his people
iv	A single certainty among other less definite facts
v	An overview of the external buildings and areas
vi	A pyramid design that others copied
vii	An idea for changing the design of burial structures
viii	An incredible experience despite the few remains
ix	The answers to some unexpected questions

14 Paragraph **A**

15 Paragraph **B**

16 Paragraph **C**

17 Paragraph **D**

18 Paragraph **E**

19 Paragraph **F**

20 Paragraph **G**

The Step Pyramid of Djoser

A The pyramids are the most famous monuments of ancient Egypt and still hold enormous interest for people in the present day. These grand, impressive tributes to the memory of the Egyptian kings have become linked with the country even though other cultures, such as the Chinese and Mayan, also built pyramids. The evolution of the pyramid form has been written and argued about for centuries. However, there is no question that, as far as Egypt is concerned, it began with one monument to one king designed by one brilliant architect: the Step Pyramid of Djoser at Saqqara.

B Djoser was the first king of the Third Dynasty of Egypt and the first to build in stone. Prior to Djoser's reign, tombs were rectangular monuments made of dried clay brick, which covered underground passages where the deceased person was buried. For reasons which remain unclear, Djoser's main official, whose name was Imhotep, conceived of building a taller, more impressive tomb for his king by stacking stone slabs on top of one another, progressively making them smaller, to form the shape now known as the Step Pyramid. Djoser is thought to have reigned for 19 years, but some historians and scholars attribute a much longer time for his rule, owing to the number and size of the monuments he built.

C The Step Pyramid has been thoroughly examined and investigated over the last century, and it is now known that the building process went through many different stages. Historian Marc Van de Mieroop comments on this, writing 'Much experimentation was involved, which is especially clear in the construction of the pyramid in the center of the complex. It had several plans … before it became the first Step Pyramid in history, piling six levels on top of one another … The weight of the enormous mass was a challenge for the builders, who placed the stones at an inward incline in order to prevent the monument breaking up.'

D When finally completed, the Step Pyramid rose 62 meters high and was the tallest structure of its time. The complex in which it was built was the size of a city in ancient Egypt and included a temple, courtyards, shrines, and living quarters for the priests. It covered a region of 16 hectares and was surrounded by a wall 10.5 meters high. The wall had 13 false doors cut into it with only one true entrance cut into the south-east corner; the entire wall was then ringed by a trench 750 meters long and 40 meters wide. The false doors and the trench were incorporated into the complex to discourage unwanted visitors. If someone wished to enter, he or she would have needed to know in advance how to find the location of the true opening in the wall. Djoser was so proud of his accomplishment that he broke the tradition of having only his own name on the monument and had Imhotep's name carved on it as well.

E The burial chamber of the tomb, where the king's body was laid to rest, was dug beneath the base of the pyramid, surrounded by a vast maze of long tunnels that had rooms off them to discourage robbers. One of the most mysterious discoveries found inside the pyramid was a large number of stone vessels. Over 40,000 of these vessels, of various forms and shapes, were discovered in storerooms off the pyramid's underground passages. They are inscribed with the names of rulers from the First and Second Dynasties of Egypt and made from different kinds of stone. There is no agreement among scholars and archaeologists on why the vessels were placed in the tomb of Djoser or what they were supposed to represent. The archaeologist Jean-Philippe Lauer, who excavated most of the pyramid and complex, believes they were originally stored and then given a 'proper burial' by Djoser in his pyramid to honor his predecessors. There are other historians, however, who claim the vessels were dumped into the shafts as yet another attempt to prevent grave robbers from getting to the king's burial chamber.

F Unfortunately, all of the precautions and intricate design of the underground network did not prevent ancient robbers from finding a way in. Djoser's grave goods, and even his body, were stolen at some point in the past and all archaeologists found were a small number of his valuables overlooked by the thieves. There was enough left throughout the pyramid and its complex, however, to astonish and amaze the archaeologists who excavated it.

G Egyptologist Miroslav Verner writes, 'Few monuments hold a place in human history as significant as that of the Step Pyramid in Saqqara … It can be said without exaggeration that this pyramid complex constitutes a milestone in the evolution of monumental stone architecture in Egypt and in the world as a whole.' The Step Pyramid was a revolutionary advance in architecture and became the archetype which all the other great pyramid builders of Egypt would follow.

Questions 21–24

Complete the notes below.

*Choose **ONE WORD ONLY** from the passage for each answer.*

Write your answers in boxes 21–24 on your answer sheet.

The Step Pyramid of Djoser

The complex that includes the Step Pyramid and its surroundings is considered to be as big as an Egyptian **21** ..... of the past. The area outside the pyramid included accommodation that was occupied by **22** ..... , along with many other buildings and features.

A wall ran around the outside of the complex and a number of false entrances were built into this. In addition, a long **23** ..... encircled the wall. As a result, any visitors who had not been invited were cleverly prevented from entering the pyramid grounds unless they knew the **24** ..... of the real entrance.

Questions 25–26

*Choose **TWO** letters, **A–E**.*

Write the correct letters in boxes 25 and 26 on your answer sheet.

Which **TWO** of the following points does the writer make about King Djoser?

A Initially he had to be persuaded to build in stone rather than clay.
B There is disagreement concerning the length of his reign.
C He failed to appreciate Imhotep's part in the design of the Step Pyramid.
D A few of his possessions were still in his tomb when archaeologists found it.
E He criticised the design and construction of other pyramids in Egypt.

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READING PASSAGE 3

*You should spend about 20 minutes on **Questions 27–40**, which are based on Reading Passage 3 below.*

The future of work

According to a leading business consultancy, 3–14% of the global workforce will need to switch to a different occupation within the next 10–15 years, and all workers will need to adapt as their occupations evolve alongside increasingly capable machines. Automation – or 'embodied artificial intelligence' (AI) – is one aspect of the disruptive effects of technology on the labour market. 'Disembodied AI', like the algorithms running in our smartphones, is another.

Dr Stella Pachidi from Cambridge Judge Business School believes that some of the most fundamental changes are happening as a result of the 'algorithmication' of jobs that are dependent on data rather than on production – the so-called knowledge economy. Algorithms are capable of learning from data to undertake tasks that previously needed human judgement, such as reading legal contracts, analysing medical scans and gathering market intelligence.

'In many cases, they can outperform humans,' says Pachidi. 'Organisations are attracted to using algorithms because they want to make choices based on what they consider is "perfect information", as well as to reduce costs and enhance productivity.'

'But these enhancements are not without consequences,' says Pachidi. 'If routine cognitive tasks are taken over by AI, how do professions develop their future experts?' she asks. 'One way of learning about a job is "legitimate peripheral participation" – a novice stands next to experts and learns by observation. If this isn't happening, then you need to find new ways to learn.'

Another issue is the extent to which the technology influences or even controls the workforce. For over two years, Pachidi monitored a telecommunications company. 'The way telecoms salespeople work is through personal and frequent contact with clients, using the benefit of experience to assess a situation and reach a decision. However, the company had started using a[n] … algorithm that defined when account managers should contact certain customers about which kinds of campaigns and what to offer them.'

The algorithm – usually built by external designers – often becomes the keeper of knowledge, she explains. In cases like this, Pachidi believes, a short-sighted view begins to creep into working practices whereby workers learn through the 'algorithm's eyes' and become dependent on its instructions. Alternative explorations – where experimentation and human instinct lead to progress and new ideas – are effectively discouraged.

Pachidi and colleagues even observed people developing strategies to make the algorithm work to their own advantage. 'We are seeing cases where workers feed the algorithm with false data to reach their targets,' she reports.

It's scenarios like these that many researchers are working to avoid. Their objective is to make AI technologies more trustworthy and transparent, so that organisations and individuals understand how AI decisions are made. In the meantime, says Pachidi, 'We need to make sure we fully understand the dilemmas that this new world raises regarding expertise, occupational boundaries and control.'

Economist Professor Hamish Low believes that the future of work will involve major transitions across the whole life course for everyone: 'The traditional trajectory of full-time education followed by full-time work followed by a pensioned retirement is a thing of the past,' says Low. Instead, he envisages a multistage employment life: one where retraining happens across the life course, and where multiple jobs and no job happen by choice at different stages.

On the subject of job losses, Low believes the predictions are founded on a fallacy: 'It assumes that the number of jobs is fixed. If in 30 years, half of 100 jobs are being carried out by robots, that doesn't mean we are left with just 50 jobs for humans. The number of jobs will increase: we would expect there to be 150 jobs.'

Dr Ewan McGaughey, at Cambridge's Centre for Business Research and King's College London, agrees that 'apocalyptic' views about the future of work are misguided. 'It's the laws that restrict the supply of capital to the job market, not the advent of new technologies that causes unemployment.'

His recently published research answers the question of whether automation, AI and robotics will mean a 'jobless future' by looking at the causes of unemployment. 'History is clear that change can mean redundancies. But social policies can tackle this through retraining and redeployment.'

He adds: 'If there is going to be change to jobs as a result of AI and robotics then I'd like to see governments seizing the opportunity to improve policy to enforce good job security. We can "reprogramme" the law to prepare for a fairer future of work and leisure.' McGaughey's findings are a call to arms to leaders of organisations, governments and banks to pre-empt the coming changes with bold new policies that guarantee full employment, fair incomes and a thriving economic democracy.

'The promises of these new technologies are astounding. They deliver humankind the capacity to live in a way that nobody could have once imagined,' he adds. 'Just as the industrial revolution brought people past subsistence agriculture, and the corporate revolution enabled mass production, a third revolution has been pronounced. But it will not only be one of technology. The next revolution will be social.'

Questions 27–30

*Choose the correct letter, **A**, **B**, **C** or **D**.*

Write the correct letter in boxes 27–30 on your answer sheet.

27 The first paragraph tells us about

A the kinds of jobs that will be most affected by the growth of AI.
B the extent to which AI will alter the nature of the work that people do.
C the proportion of the world's labour force who will have jobs in AI in the future.
D the difference between ways that embodied and disembodied AI will impact on workers.

28 According to the second paragraph, what is Stella Pachidi's view of the 'knowledge economy'?

A It is having an influence on the number of jobs available.
B It is changing people's attitudes towards their occupations.
C It is the main reason why the production sector is declining.
D It is a key factor driving current developments in the workplace.

29 What did Pachidi observe at the telecommunications company?

A staff disagreeing with the recommendations of AI
B staff feeling resentful about the intrusion of AI in their work
C staff making sure that AI produces the results that they want
D staff allowing AI to carry out tasks they ought to do themselves

30 In his recently published research, Ewan McGaughey

A challenges the idea that redundancy is a negative thing.
B shows the profound effect of mass unemployment on society.
C highlights some differences between past and future job losses.
D illustrates how changes in the job market can be successfully handled.

Questions 31–34

*Complete the summary using the list of words, **A–G**, below.*

*Write the correct letter, **A–G**, in boxes 31–34 on your answer sheet.*

The 'algorithmication' of jobs

Stella Pachidi of Cambridge Judge Business School has been focusing on the 'algorithmication' of jobs which rely not on production but on **31** ..... .

While monitoring a telecommunications company, Pachidi observed a growing **32** ..... on the recommendations made by AI, as workers begin to learn through the 'algorithm's eyes'. Meanwhile, staff are deterred from experimenting and using their own **33** ..... , and are therefore prevented from achieving innovation.

To avoid the kind of situations which Pachidi observed, researchers are trying to make AI's decision-making process easier to comprehend, and to increase users' **34** ..... with regard to the technology.

A	pressure	**B**	satisfaction	**C**	intuition
D	promotion	**E**	reliance	**F**	confidence
G	information				

Questions 35–40

Look at the following statements (Questions 35–40) and the list of people below.

Match each statement with the correct person, ***A****,* ***B*** *or* ***C****.*

Write the correct letter, ***A****,* ***B*** *or* ***C****, in boxes 35–40 on your answer sheet.*

NB *You may use any letter more than once.*

35 Greater levels of automation will not result in lower employment.

36 There are several reasons why AI is appealing to businesses.

37 AI's potential to transform people's lives has parallels with major cultural shifts which occurred in previous eras.

38 It is important to be aware of the range of problems that AI causes.

39 People are going to follow a less conventional career path than in the past.

40 Authorities should take measures to ensure that there will be adequately paid work for everyone.

List of people	
A	Stella Pachidi
B	Hamish Low
C	Ewan McGaughey

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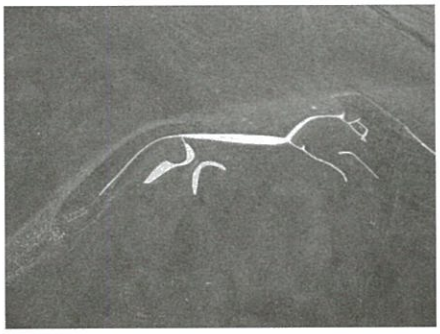
READING

READING PASSAGE 1

*You should spend about 20 minutes on **Questions 1–13**, which are based on Reading Passage 1 below.*

The White Horse of Uffington



The cutting of huge figures or 'geoglyphs' into the earth of English hillsides has taken place for more than 3,000 years. There are 56 hill figures scattered around England, with the vast majority on the chalk downlands of the country's southern counties. The figures include giants, horses, crosses and regimental badges. Although the majority of these geoglyphs date within the last 300 years or so, there are one or two that are much older.

The most famous of these figures is perhaps also the most mysterious – the Uffington White Horse in Oxfordshire. The White Horse has recently been re-dated and shown to be even older than its previously assigned ancient pre-Roman Iron Age* date. More controversial is the date of the enigmatic Long Man of Wilmington in Sussex. While many historians are convinced the figure is prehistoric, others believe that it was the work of an artistic monk from a nearby priory and was created between the 11th and 15th centuries.

The method of cutting these huge figures was simply to remove the overlying grass to reveal the gleaming white chalk below. However, the grass would soon grow over the geoglyph again unless it was regularly cleaned or scoured by a fairly large team of people. One reason that the vast majority of hill figures have disappeared is that when the traditions associated with the figures faded, people no longer bothered or remembered to clear away the grass to expose the chalk outline. Furthermore, over hundreds of years the outlines would sometimes change due to people not always cutting in exactly the same place, thus creating a different shape to the original geoglyph. The fact that any ancient hill figures survive at all in England today is testament to the strength and continuity of local customs and beliefs which, in one case at least, must stretch back over millennia.

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*Iron Age: a period (in Britain 800 BCE – 43 CE) that is characterised by the use of iron tools

The Uffington White Horse is a unique, stylised representation of a horse consisting of a long, sleek back, thin disjointed legs, a streaming tail, and a bird-like beaked head. The elegant creature almost melts into the landscape. The horse is situated 2.5 km from Uffington village on a steep slope close to the Late Bronze Age* (c. 7th century BCE) hillfort of Uffington Castle and below the Ridgeway, a long-distance Neolithic** track.

The Uffington Horse is also surrounded by Bronze Age burial mounds. It is not far from the Bronze Age cemetery of Lambourn Seven Barrows, which consists of more than 30 well-preserved burial mounds. The carving has been placed in such a way as to make it extremely difficult to see from close quarters, and like many geoglyphs is best appreciated from the air. Nevertheless, there are certain areas of the Vale of the White Horse, the valley containing and named after the enigmatic creature, from which an adequate impression may be gained. Indeed on a clear day the carving can be seen from up to 30 km away.

The earliest evidence of a horse at Uffington is from the 1070s CE when 'White Horse Hill' is mentioned in documents from the nearby Abbey of Abingdon, and the first reference to the horse itself is soon after, in 1190 CE. However, the carving is believed to date back much further than that. Due to the similarity of the Uffington White Horse to the stylised depictions of horses on 1st century BCE coins, it had been thought that the creature must also date to that period.

However, in 1995 Optically Stimulated Luminescence (OSL) testing was carried out by the Oxford Archaeological Unit on soil from two of the lower layers of the horse's body, and from another cut near the base. The result was a date for the horse's construction somewhere between 1400 and 600 BCE – in other words, it had a Late Bronze Age or Early Iron Age origin.

The latter end of this date range would tie the carving of the horse in with occupation of the nearby Uffington hillfort, indicating that it may represent a tribal emblem marking the land of the inhabitants of the hillfort. Alternatively, the carving may have been carried out during a Bronze or Iron Age ritual. Some researchers see the horse as representing the Celtic*** horse goddess Epona, who was worshipped as a protector of horses, and for her associations with fertility. However, the cult of Epona was not imported from Gaul (France) until around the first century CE. This date is at least six centuries after the Uffington Horse was probably carved. Nevertheless, the horse had great ritual and economic significance during the Bronze and Iron Ages, as attested by its depictions on jewellery and other metal objects. It is possible that the carving represents a goddess in native mythology, such as Rhiannon, described in later Welsh mythology as a beautiful woman dressed in gold and riding a white horse.

The fact that geoglyphs can disappear easily, along with their associated rituals and meaning, indicates that they were never intended to be anything more than temporary gestures. But this does not lessen their importance. These giant carvings are a fascinating glimpse into the minds of their creators and how they viewed the landscape in which they lived.

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*Bronze Age: a period (in Britain c. 2,500 BCE – 800 BCE) that is characterised by the development of bronze tools

**Neolithic: a period (in Britain c. 4,000 BCE – c. 2,500 BCE) that is significant for the spread of agricultural practices, and the use of stone tools

***Celtic: an ancient people who migrated from Europe to Britain before the Romans

Questions 1–8

Do the following statements agree with the information given in Reading Passage 1?

In boxes 1–8 on your answer sheet, write

TRUE	*if the statement agrees with the information*
FALSE	*if the statement contradicts the information*
NOT GIVEN	*if there is no information on this*

1 Most geoglyphs in England are located in a particular area of the country.

2 There are more geoglyphs in the shape of a horse than any other creature.

3 A recent dating of the Uffington White Horse indicates that people were mistaken about its age.

4 Historians have come to an agreement about the origins of the Long Man of Wilmington.

5 Geoglyphs were created by people placing white chalk on the hillside.

6 Many geoglyphs in England are no longer visible.

7 The shape of some geoglyphs has been altered over time.

8 The fame of the Uffington White Horse is due to its size.

Questions 9–13

Complete the notes below.

*Choose **ONE WORD ONLY** from the passage for each answer.*

Write your answers in boxes 9–13 on your answer sheet.

The Uffington White Horse

The location of the Uffington White Horse:

- a distance of 2.5 km from Uffington village
- near an ancient road known as the **9** .....
- close to an ancient cemetery that has a number of burial mounds

Dating the Uffington White Horse:

- first reference to White Horse Hill appears in **10** ..... from the 1070s
- horses shown on coins from the period 100 BCE – 1 BCE are similar in appearance
- according to analysis of the surrounding **11** ..... , the Horse is Late Bronze Age / Early Iron Age

Possible reasons for creation of the Uffington White Horse:

- an emblem to indicate land ownership
- formed part of an ancient ritual
- was a representation of goddess Epona – associated with protection of horses and **12** .....
- was a representation of a Welsh goddess called **13** .....

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READING PASSAGE 2

*You should spend about 20 minutes on **Questions 14–26**, which are based on Reading Passage 2 below.*

I contain multitudes

Wendy Moore reviews Ed Yong's book about microbes

Microbes, most of them bacteria, have populated this planet since long before animal life developed and they will outlive us. Invisible to the naked eye, they are ubiquitous. They inhabit the soil, air, rocks and water and are present within every form of life, from seaweed and coral to dogs and humans. And, as Yong explains in his utterly absorbing and hugely important book, we mess with them at our peril.

Every species has its own colony of microbes, called a 'microbiome', and these microbes vary not only between species but also between individuals and within different parts of each individual. What is amazing is that while the number of human cells in the average person is about 30 trillion, the number of microbial ones is higher – about 39 trillion. At best, Yong informs us, we are only 50 per cent human. Indeed, some scientists even suggest we should think of each species and its microbes as a single unit, dubbed a 'holobiont'.

In each human there are microbes that live only in the stomach, the mouth or the armpit and by and large they do so peacefully. So 'bad' microbes are just microbes out of context. Microbes that sit contentedly in the human gut (where there are more microbes than there are stars in the galaxy) can become deadly if they find their way into the bloodstream. These communities are constantly changing too. The right hand shares just one sixth of its microbes with the left hand. And, of course, we are surrounded by microbes. Every time we eat, we swallow a million microbes in each gram of food; we are continually swapping microbes with other humans, pets and the world at large.

It's a fascinating topic and Yong, a young British science journalist, is an extraordinarily adept guide. Writing with lightness and panache, he has a knack of explaining complex science in terms that are both easy to understand and totally enthralling. Yong is on a mission. Leading us gently by the hand, he takes us into the world of microbes – a bizarre, alien planet – in a bid to persuade us to love them as much as he does. By the end, we do.

For most of human history we had no idea that microbes existed. The first man to see these extraordinarily potent creatures was a Dutch lens-maker called Antony van Leeuwenhoek in the 1670s. Using microscopes of his own design that could magnify up to 270 times, he examined a drop of water from a nearby lake and found it teeming with tiny creatures he called 'animalcules'. It wasn't until nearly two hundred years later that the research of French biologist Louis Pasteur indicated that some microbes caused disease. It was Pasteur's 'germ theory' that gave bacteria the poor image that endures today.

Yong's book is in many ways a plea for microbial tolerance, pointing out that while fewer than one hundred species of bacteria bring disease, many thousands more play a vital role in maintaining our health. The book also acknowledges that our attitude towards bacteria is not a simple one. We tend to see the dangers posed by bacteria, yet at the same time we are sold yoghurts and drinks that supposedly nurture 'friendly' bacteria. In reality, says Yong, bacteria should not be viewed as either friends or foes, villains or heroes. Instead we should realise we have a symbiotic relationship, that can be mutually beneficial or mutually destructive.

What then do these millions of organisms do? The answer is pretty much everything. New research is now unravelling the ways in which bacteria aid digestion, regulate our immune systems, eliminate toxins, produce vitamins, affect our behaviour and even combat obesity. 'They actually help us become who we are,' says Yong. But we are facing a growing problem. Our obsession with hygiene, our overuse of antibiotics and our unhealthy, low-fibre diets are disrupting the bacterial balance and may be responsible for soaring rates of allergies and immune problems, such as inflammatory bowel disease (IBD).

The most recent research actually turns accepted norms upside down. For example, there are studies indicating that the excessive use of household detergents and antibacterial products actually destroys the microbes that normally keep the more dangerous germs at bay. Other studies show that keeping a dog as a pet gives children early exposure to a diverse range of bacteria, which may help protect them against allergies later.

The readers of Yong's book must be prepared for a decidedly unglamorous world. Among the less appealing case studies is one about a fungus that is wiping out entire populations of frogs and that can be halted by a rare microbial bacterium. Another is about squid that carry luminescent bacteria that protect them against predators. However, if you can overcome your distaste for some of the investigations, the reasons for Yong's enthusiasm become clear. The microbial world is a place of wonder. Already, in an attempt to stop mosquitoes spreading dengue fever – a disease that infects 400 million people a year – mosquitoes are being loaded with a bacterium to block the disease. In the future, our ability to manipulate microbes means we could construct buildings with useful microbes built into their walls to fight off infections. Just imagine a neonatal hospital ward coated in a specially mixed cocktail of microbes so that babies get the best start in life.

Questions 14–16

*Choose the correct letter, **A**, **B**, **C** or **D**.*

Write the correct letter in boxes 14–16 on your answer sheet.

14 What point does the writer make about microbes in the first paragraph?

- **A** They adapt quickly to their environment.
- **B** The risk they pose has been exaggerated.
- **C** They are more plentiful in animal life than plant life.
- **D** They will continue to exist for longer than the human race.

15 In the second paragraph, the writer is impressed by the fact that

- **A** each species tends to have vastly different microbes.
- **B** some parts of the body contain relatively few microbes.
- **C** the average individual has more microbial cells than human ones.
- **D** scientists have limited understanding of how microbial cells behave.

16 What is the writer doing in the fifth paragraph?

- **A** explaining how a discovery was made
- **B** comparing scientists' theories about microbes
- **C** describing confusion among scientists
- **D** giving details of how microbes cause disease

Questions 17–20

Complete the summary using the list of words, ***A–H****, below.*

Write the correct letter, ***A–H****, in boxes 17–20 on your answer sheet.*

We should be more tolerant of microbes

Yong's book argues that we should be more tolerant of microbes. Many have a beneficial effect, and only a relatively small number lead to **17** ..... . And although it is misleading to think of microbes as 'friendly', we should also stop thinking of them as the enemy. In fact, we should accept that our relationship with microbes is one based on **18** ..... .

New research shows that microbes have numerous benefits for humans. Amongst other things, they aid digestion, remove poisons, produce vitamins and may even help reduce obesity. However, there is a growing problem. Our poor **19** ..... , our overuse of antibiotics, and our excessive focus on **20** ..... are upsetting the bacterial balance and may be contributing to the huge increase in allergies and immune system problems.

A	solution	**B**	partnership	**C**	destruction
D	exaggeration	**E**	cleanliness	**F**	regulations
G	illness	**H**	nutrition		

Questions 21–26

Do the following statements agree with the claims of the writer in Reading Passage 2?

In boxes 21–26 on your answer sheet, write

YES	*if the statement agrees with the claims of the writer*
NO	*if the statement contradicts the claims of the writer*
NOT GIVEN	*if it is impossible to say what the writer thinks about this*

21 It is possible that using antibacterial products in the home fails to have the desired effect.

22 It is a good idea to ensure that children come into contact with as few bacteria as possible.

23 Yong's book contains more case studies than are necessary.

24 The case study about bacteria that prevent squid from being attacked may have limited appeal.

25 Efforts to control dengue fever have been surprisingly successful.

26 Microbes that reduce the risk of infection have already been put inside the walls of some hospital wards.

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READING PASSAGE 3

*You should spend about 20 minutes on **Questions 27–40**, which are based on Reading Passage 3 below.*

How to make wise decisions

Across cultures, wisdom has been considered one of the most revered human qualities. Although the truly wise may seem few and far between, empirical research examining wisdom suggests that it isn't an exceptional trait possessed by a small handful of bearded philosophers after all – in fact, the latest studies suggest that most of us have the ability to make wise decisions, given the right context.

'It appears that experiential, situational, and cultural factors are even more powerful in shaping wisdom than previously imagined,' says Associate Professor Igor Grossmann of the University of Waterloo in Ontario, Canada. 'Recent empirical findings from cognitive, developmental, social, and personality psychology cumulatively suggest that people's ability to reason wisely varies dramatically across experiential and situational contexts. Understanding the role of such contextual factors offers unique insights into understanding wisdom in daily life, as well as how it can be enhanced and taught.'

It seems that it's not so much that some people simply possess wisdom and others lack it, but that our ability to reason wisely depends on a variety of external factors. 'It is impossible to characterize thought processes attributed to wisdom without considering the role of contextual factors,' explains Grossmann. 'In other words, wisdom is not solely an "inner quality" but rather unfolds as a function of situations people happen to be in. Some situations are more likely to promote wisdom than others.'

Coming up with a definition of wisdom is challenging, but Grossmann and his colleagues have identified four key characteristics as part of a framework of wise reasoning. One is intellectual humility or recognition of the limits of our own knowledge, and another is appreciation of perspectives wider than the issue at hand. Sensitivity to the possibility of change in social relations is also key, along with compromise or integration of different attitudes and beliefs.

Grossmann and his colleagues have also found that one of the most reliable ways to support wisdom in our own day-to-day decisions is to look at scenarios from a third-party perspective, as though giving advice to a friend. Research suggests that when adopting a first-person viewpoint we focus on 'the focal features of the environment' and when we adopt a third-person, 'observer' viewpoint we reason more broadly and focus more on interpersonal and moral ideals such as justice and impartiality. Looking at problems from this more expansive viewpoint appears to foster cognitive processes related to wise decisions.

What are we to do, then, when confronted with situations like a disagreement with a spouse or negotiating a contract at work, that require us to take a personal stake? Grossmann argues that even when we aren't able to change the situation, we can still evaluate these experiences from different perspectives.

For example, in one experiment that took place during the peak of a recent economic recession, graduating college seniors were asked to reflect on their job prospects. The students were instructed to imagine their career either 'as if you were a distant observer' or 'before your own eyes as if you were right there'. Participants in the group assigned to the 'distant observer' role displayed more wisdom-related reasoning (intellectual humility and recognition of change) than did participants in the control group.

In another study, couples in long-term romantic relationships were instructed to visualize an unresolved relationship conflict either through the eyes of an outsider or from their own perspective. Participants then discussed the incident with their partner for 10 minutes, after which they wrote down their thoughts about it. Couples in the 'other's eyes' condition were significantly more likely to rely on wise reasoning – recognizing others' perspectives and searching for a compromise – compared to the couples in the egocentric condition.

'Ego-decentering promotes greater focus on others and enables a bigger picture, conceptual view of the experience, affording recognition of intellectual humility and change,' says Grossmann.

We might associate wisdom with intelligence or particular personality traits, but research shows only a small positive relationship between wise thinking and crystallized intelligence and the personality traits of openness and agreeableness. 'It is remarkable how much people can vary in their wisdom from one situation to the next, and how much stronger such contextual effects are for understanding the relationship between wise judgment and its social and affective outcomes as compared to the generalized "traits",' Grossmann explains. 'That is, knowing how wisely a person behaves in a given situation is more informative for understanding their emotions or likelihood to forgive [or] retaliate as compared to knowing whether the person may be wise "in general".'

Questions 27–30

*Choose the correct letter, **A**, **B**, **C** or **D**.*

Write the correct letter in boxes 27–30 on your answer sheet.

27 What point does the writer make in the first paragraph?

A Wisdom appears to be unique to the human race.
B A basic assumption about wisdom may be wrong.
C Concepts of wisdom may depend on the society we belong to.
D There is still much to be discovered about the nature of wisdom.

28 What does Igor Grossmann suggest about the ability to make wise decisions?

A It can vary greatly from one person to another.
B Earlier research into it was based on unreliable data.
C The importance of certain influences on it was underestimated.
D Various branches of psychology define it according to their own criteria.

29 According to the third paragraph, Grossmann claims that the level of wisdom an individual shows

A can be greater than they think it is.
B will be different in different circumstances.
C may be determined by particular aspects of their personality.
D should develop over time as a result of their life experiences.

30 What is described in the fifth paragraph?

A a difficulty encountered when attempting to reason wisely
B an example of the type of person who is likely to reason wisely
C a controversial view about the benefits of reasoning wisely
D a recommended strategy that can help people to reason wisely

Questions 31–35

*Complete the summary using the list of words, **A–J**, below.*

*Write the correct letter, **A–J**, in boxes 31–35 on your answer sheet.*

The characteristics of wise reasoning

Igor Grossmann and colleagues have established four characteristics which enable us to make wise decisions. It is important to have a certain degree of **31** ..... regarding the extent of our knowledge, and to take into account **32** ..... which may not be the same as our own. We should also be able to take a broad **33** ..... of any situation. Another key characteristic is being aware of the likelihood of alterations in the way that people relate to each other.

Grossmann also believes that it is better to regard scenarios with **34** ..... . By avoiding the first-person perspective, we focus more on **35** ..... and on other moral ideals, which in turn leads to wiser decision-making.

A	opinions	**B**	confidence	**C**	view
D	modesty	**E**	problems	**F**	objectivity
G	fairness	**H**	experiences	**I**	range
J	reasons				

Questions 36–40

Do the following statements agree with the information given in Reading Passage 3?

In boxes 36–40 on your answer sheet, write

TRUE	*if the statement agrees with the information*
FALSE	*if the statement contradicts the information*
NOT GIVEN	*if there is no information on this*

36 Students participating in the job prospects experiment could choose one of two perspectives to take.

37 Participants in the couples experiment were aware that they were taking part in a study about wise reasoning.

38 In the couples experiments, the length of the couples' relationships had an impact on the results.

39 In both experiments, the participants who looked at the situation from a more detached viewpoint tended to make wiser decisions.

40 Grossmann believes that a person's wisdom is determined by their intelligence to only a very limited extent.

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READING

READING PASSAGE 1

*You should spend about 20 minutes on **Questions 1–13**, which are based on Reading Passage 1 below.*

Roman shipbuilding and navigation

Shipbuilding today is based on science and ships are built using computers and sophisticated tools. Shipbuilding in ancient Rome, however, was more of an art relying on estimation, inherited techniques and personal experience. The Romans were not traditionally sailors but mostly land-based people, who learned to build ships from the people that they conquered, namely the Greeks and the Egyptians.

There are a few surviving written documents that give descriptions and representations of ancient Roman ships, including the sails and rigging. Excavated vessels also provide some clues about ancient shipbuilding techniques. Studies of these have taught us that ancient Roman shipbuilders built the outer hull first, then proceeded with the frame and the rest of the ship. Planks used to build the outer hull were initially sewn together. Starting from the 6th century BCE, they were fixed using a method called mortise and tenon, whereby one plank locked into another without the need for stitching. Then in the first centuries of the current era, Mediterranean shipbuilders shifted to another shipbuilding method, still in use today, which consisted of building the frame first and then proceeding with the hull and the other components of the ship. This method was more systematic and dramatically shortened ship construction times. The ancient Romans built large merchant ships and warships whose size and technology were unequalled until the 16th century CE.

Warships were built to be lightweight and very speedy. They had to be able to sail near the coast, which is why they had no ballast or excess load and were built with a long, narrow hull. They did not sink when damaged and often would lie crippled on the sea's surface following naval battles. They had a bronze battering ram, which was used to pierce the timber hulls or break the oars of enemy vessels. Warships used both wind (sails) and human power (oarsmen) and were therefore very fast. Eventually, Rome's navy became the largest and most powerful in the Mediterranean, and the Romans had control over what they therefore called *Mare Nostrum* meaning 'our sea'.

There were many kinds of warship. The 'trireme' was the dominant warship from the 7th to 4th century BCE. It had rowers in the top, middle and lower levels, and approximately 50 rowers in each bank. The rowers at the bottom had the most uncomfortable position as they were under the other rowers and were exposed to the water entering through the oar-holes. It is worth noting that contrary to popular perception, rowers were not slaves but mostly Roman citizens enrolled in the military. The trireme was superseded by larger ships with even more rowers.

Merchant ships were built to transport lots of cargo over long distances and at a reasonable cost. They had a wider hull, double planking and a solid interior for added stability. Unlike warships, their V-shaped hull was deep underwater, meaning that they could not sail too close to the coast. They usually had two huge side rudders located off the stern and controlled by a small tiller bar connected to a system of cables. They had from one to three masts with large square sails and a small triangular sail at the bow. Just like warships, merchant ships used oarsmen, but coordinating the hundreds of rowers in both types of ship was not an easy task. In order to assist them, music would be played on an instrument, and oars would then keep time with this.

The cargo on merchant ships included raw materials (e.g. iron bars, copper, marble and granite), and agricultural products (e.g. grain from Egypt's Nile valley). During the Empire, Rome was a huge city by ancient standards of about one million inhabitants. Goods from all over the world would come to the city through the port of Pozzuoli situated west of the bay of Naples in Italy and through the gigantic port of Ostia situated at the mouth of the Tiber River. Large merchant ships would approach the destination port and, just like today, be intercepted by a number of towboats that would drag them to the quay.

The time of travel along the many sailing routes could vary widely. Navigation in ancient Rome did not rely on sophisticated instruments such as compasses but on experience, local knowledge and observation of natural phenomena. In conditions of good visibility, seamen in the Mediterranean often had the mainland or islands in sight, which greatly facilitated navigation. They sailed by noting their position relative to a succession of recognisable landmarks. When weather conditions were not good or where land was no longer visible, Roman mariners estimated directions from the pole star or, with less accuracy, from the Sun at noon. They also estimated directions relative to the wind and swell. Overall, shipping in ancient Roman times resembled shipping today with large vessels regularly crossing the seas and bringing supplies from their Empire.

Questions 1–5

Do the following statements agree with the information given in Reading Passage 1?

In boxes 1–5 on your answer sheet, write

TRUE	*if the statement agrees with the information*
FALSE	*if the statement contradicts the information*
NOT GIVEN	*if there is no information on this*

1 The Romans' shipbuilding skills were passed on to the Greeks and the Egyptians.

2 Skilled craftsmen were needed for the mortise and tenon method of fixing planks.

3 The later practice used by Mediterranean shipbuilders involved building the hull before the frame.

4 The Romans called the Mediterranean Sea *Mare Nostrum* because they dominated its use.

5 Most rowers on ships were people from the Roman army.

Questions 6–13

Complete the summary below.

*Choose **ONE WORD ONLY** from the passage for each answer.*

Write your answers in boxes 6–13 on your answer sheet.

Warships and merchant ships

Warships were designed so that they were **6** ..... and moved quickly. They often remained afloat after battles and were able to sail close to land as they lacked any additional weight. A battering ram made of **7** ..... was included in the design for attacking and damaging the timber and oars of enemy ships. Warships, such as the 'trireme', had rowers on three different **8** ..... .

Unlike warships, merchant ships had a broad **9** ..... that lay far below the surface of the sea. Merchant ships were steered through the water with the help of large rudders and a tiller bar. They had both square and **10** ..... sails. On merchant ships and warships, **11** ..... was used to ensure rowers moved their oars in and out of the water at the same time.

Quantities of agricultural goods such as **12** ..... were transported by merchant ships to two main ports in Italy. The ships were pulled to the shore by **13** ..... . When the weather was clear and they could see islands or land, sailors used landmarks that they knew to help them navigate their route.

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READING PASSAGE 2

*You should spend about 20 minutes on **Questions 14–26**, which are based on Reading Passage 2 below.*

Climate change reveals ancient artefacts in Norway's glaciers

A Well above the treeline in Norway's highest mountains, ancient fields of ice are shrinking as Earth's climate warms. As the ice has vanished, it has been giving up the treasures it has preserved in cold storage for the last 6,000 years – items such as ancient arrows and skis from Viking Age* traders. And those artefacts have provided archaeologists with some surprising insights into how ancient Norwegians made their livings.

B Organic materials like textiles and hides are relatively rare finds at archaeological sites. This is because unless they're protected from the microorganisms that cause decay, they tend not to last long. Extreme cold is one reliable way to keep artefacts relatively fresh for a few thousand years, but once thawed out, these materials experience degradation relatively swiftly.

With climate change shrinking ice cover around the world, glacial archaeologists need to race the clock to find newly revealed artefacts, preserve them, and study them. If something fragile dries and is windblown it might very soon be lost to science, or an arrow might be exposed and then covered again by the next snow and remain well-preserved. The unpredictability means that glacial archaeologists have to be systematic in their approach to fieldwork.

C Over a nine-year period, a team of archaeologists, which included Lars Pilø of Oppland County Council, Norway, and James Barrett of the McDonald Institute for Archaeological Research, surveyed patches of ice in Oppland, an area of south-central Norway that is home to some of the country's highest mountains. Reindeer once congregated on these icy patches in the later summer months to escape biting insects, and from the late Stone Age**, hunters followed. In addition, trade routes threaded through the mountain passes of Oppland, linking settlements in Norway to the rest of Europe.

The slow but steady movement of glaciers tends to destroy anything at their bases, so the team focused on stationary patches of ice, mostly above 1,400 metres. That ice is found amid fields of frost-weathered boulders, fallen rocks, and exposed bedrock that for nine months of the year is buried beneath snow.

'Fieldwork is hard work – hiking with all our equipment, often camping on permafrost – but very rewarding. You're rescuing the archaeology, bringing the melting ice to wider attention, discovering a unique environmental history and really connecting with the natural environment,' says Barrett.

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*Viking Age: a period of European history from around 700 CE to around 1050 CE when Scandinavian Vikings migrated throughout Europe by means of trade and warfare

** The Stone Age: a period in early history that began about 3.4 million years ago

D At the edges of the contracting ice patches, archaeologists found more than 2,000 artefacts, which formed a material record that ran from 4,000 BCE to the beginnings of the Renaissance in the 14th century. Many of the artefacts are associated with hunting. Hunters would have easily misplaced arrows and they often discarded broken bows rather than take them all the way home. Other items could have been used by hunters traversing the high mountain passes of Oppland: all-purpose items like tools, skis, and horse tack.

E Barrett's team radiocarbon-dated 153 of the artefacts and compared those dates to the timing of major environmental changes in the region – such as periods of cooling or warming – and major social and economic shifts – such as the growth of farming settlements and the spread of international trade networks leading up to the Viking Age. They found that some periods had produced lots of artefacts, which indicates that people had been pretty active in the mountains during those times. But there were few or no signs of activity during other periods.

F What was surprising, according to Barrett, was the timing of these periods. Oppland's mountains present daunting terrain and in periods of extreme cold, glaciers could block the higher mountain passes and make travel in the upper reaches of the mountains extremely difficult. Archaeologists assumed people would stick to lower elevations during a time like the Late Antique Little Ice Age, a short period of deeper-than-usual cold from about 536–600 CE. But it turned out that hunters kept regularly venturing into the mountains even when the climate turned cold, based on the amount of stuff they had apparently dropped there.

'Remarkably, though, the finds from the ice may have continued through this period, perhaps suggesting that the importance of mountain hunting increased to supplement failing agricultural harvests in times of low temperatures,' says Barrett. A colder turn in the Scandinavian climate would likely have meant widespread crop failures, so more people would have depended on hunting to make up for those losses.

G Many of the artefacts Barrett's team recovered date from the beginning of the Viking Age, the 700s through to the 900s CE. Trade networks connecting Scandinavia with Europe and the Middle East were expanding around this time. Although we usually think of ships when we think of Scandinavian expansion, these recent discoveries show that plenty of goods travelled on overland routes, like the mountain passes of Oppland. And growing Norwegian towns, along with export markets, would have created a booming demand for hides to fight off the cold, as well as antlers to make useful things like combs. Business must have been good for hunters.

H Norway's mountains are probably still hiding a lot of history – and prehistory – in remote ice patches. When Barrett's team looked at the dates for their sample of 153 artefacts, they noticed a gap with almost no artefacts from about 3,800 to 2,200 BCE. In fact, archaeological finds from that period are rare all over Norway. The researchers say that could be because many of those artefacts have already disintegrated or are still frozen in the ice. That means archaeologists could be extracting some of those artefacts from retreating ice in years to come.

Questions 14–19

Reading Passage 2 has eight sections, **A–H**.

Which section contains the following information?

*Write the correct letter, **A–H**, in boxes 14–19 on your answer sheet.*

14 an explanation for weapons being left behind in the mountains

15 a reference to the physical difficulties involved in an archaeological expedition

16 an explanation of why less food may have been available

17 a reference to the possibility of future archaeological discoveries

18 examples of items that would have been traded

19 a reference to the pressure archaeologists are under to work quickly

Questions 20–22

Complete the summary below.

*Choose **ONE WORD ONLY** from the passage for each answer.*

Write your answers in boxes 20–22 on your answer sheet.

Interesting finds at an archaeological site

Organic materials such as animal skins and textiles are not discovered very often at archaeological sites. They have little protection against **20** ..... , which means that they decay relatively quickly. But this is not always the case. If temperatures are low enough, fragile artefacts can be preserved for thousands of years.

A team of archaeologists have been working in the mountains in Oppland in Norway to recover artefacts revealed by shrinking ice cover. In the past, there were trade routes through these mountains and **21** ..... gathered there in the summer months to avoid being attacked by **22** ..... on lower ground. The people who used these mountains left things behind and it is those objects that are of interest to archaeologists.

Questions 23 and 24

*Choose **TWO** letters, **A–E**.*

Write the correct letters in boxes 23 and 24 on your answer sheet.

Which **TWO** of the following statements does the writer make about the discoveries of Barrett's team?

A Artefacts found in the higher mountain passes were limited to skiing equipment.
B Hunters went into the mountains even during periods of extreme cold.
C The number of artefacts from certain time periods was relatively low.
D Radiocarbon dating of artefacts produced some unreliable results.
E More artefacts were found in Oppland than at any other mountain site.

Questions 25 and 26

*Choose **TWO** letters, **A–E**.*

Write the correct letters in boxes 25 and 26 on your answer sheet.

Which **TWO** of the following statements does the writer make about the Viking Age?

A Hunters at this time benefited from an increased demand for goods.
B The beginning of the period saw the greatest growth in the wealth of Vikings.
C Vikings did not rely on ships alone to transport goods.
D Norwegian towns at this time attracted traders from around the world.
E Vikings were primarily interested in their trading links with the Middle East.

READING PASSAGE 3

*You should spend about 20 minutes on **Questions 27–40**, which are based on Reading Passage 3 below.*

Plant 'thermometer' triggers springtime growth by measuring night-time heat

A photoreceptor molecule in plant cells has been found to have a second job as a thermometer after dark – allowing plants to read seasonal temperature changes. Scientists say the discovery could help breed crops that are more resilient to the temperatures expected to result from climate change

A An international team of scientists led by the University of Cambridge has discovered that the 'thermometer' molecule in plants enables them to develop according to seasonal temperature changes. Researchers have revealed that molecules called phytochromes – used by plants to detect light during the day – actually change their function in darkness to become cellular temperature gauges that measure the heat of the night.

The new findings, published in the journal *Science*, show that phytochromes control genetic switches in response to temperature as well as light to dictate plant development.

B At night, these molecules change states, and the pace at which they change is 'directly proportional to temperature', say scientists, who compare phytochromes to mercury in a thermometer. The warmer it is, the faster the molecular change – stimulating plant growth.

C Farmers and gardeners have known for hundreds of years how responsive plants are to temperature: warm winters cause many trees and flowers to bud early, something humans have long used to predict weather and harvest times for the coming year. The latest research pinpoints for the first time a molecular mechanism in plants that reacts to temperature – often triggering the buds of spring we long to see at the end of winter.

D With weather and temperatures set to become ever more unpredictable due to climate change, researchers say the discovery that this light-sensing molecule also functions as the internal thermometer in plant cells could help us breed tougher crops. 'It is estimated that agricultural yields will need to double by 2050, but climate change is a major threat to achieving this. Key crops such as wheat and rice are sensitive to high temperatures. Thermal stress reduces crop yields by around 10% for every one degree increase in temperature,' says lead researcher Dr Philip Wigge from Cambridge's Sainsbury Laboratory. 'Discovering the molecules that allow plants to sense temperature has the potential to accelerate the breeding of crops resilient to thermal stress and climate change.'

E In their active state, phytochrome molecules bind themselves to DNA to restrict plant growth. During the day, sunlight activates the molecules, slowing down growth. If a plant finds itself in shade, phytochromes are quickly inactivated – enabling it to grow faster to find sunlight again. This is how plants compete to escape each other's shade. 'Light-driven changes to phytochrome activity occur very fast, in less than a second,' says Wigge.

At night, however, it's a different story. Instead of a rapid deactivation following sundown, the molecules gradually change from their active to inactive state. This is called 'dark reversion'. 'Just as mercury rises in a thermometer, the rate at which phytochromes revert to their inactive state during the night is a direct measure of temperature,' says Wigge.

F 'The lower the temperature, the slower the rate at which phytochromes revert to inactivity, so the molecules spend more time in their active, growth-suppressing state. This is why plants are slower to grow in winter. Warm temperatures accelerate dark reversion, so that phytochromes rapidly reach an inactive state and detach themselves from the plant's DNA – allowing genes to be expressed and plant growth to resume.' Wigge believes phytochrome thermo-sensing evolved at a later stage, and co-opted the biological network already used for light-based growth during the downtime of night.

G Some plants mainly use day length as an indicator of the season. Other species, such as daffodils, have considerable temperature sensitivity, and can flower months in advance during a warm winter. In fact, the discovery of the dual role of phytochromes provides the science behind a well-known rhyme long used to predict the coming season: oak before ash we'll have a splash, ash before oak we're in for a soak.

Wigge explains: 'Oak trees rely much more on temperature, likely using phytochromes as thermometers to dictate development, whereas ash trees rely on measuring day length to determine their seasonal timing. A warmer spring, and consequently a higher likeliness of a hot summer, will result in oak leafing before ash. A cold spring will see the opposite. As the British know only too well, a colder summer is likely to be a rain-soaked one.'

H The new findings are the culmination of twelve years of research involving scientists from Germany, Argentina and the US, as well as the Cambridge team. The work was done in a model system, using a mustard plant called *Arabidopsis*, but Wigge says the phytochrome genes necessary for temperature sensing are found in crop plants as well. 'Recent advances in plant genetics now mean that scientists are able to rapidly identify the genes controlling these processes in crop plants, and even alter their activity using precise molecular "scalpels",' adds Wigge. 'Cambridge is uniquely well-positioned to do this kind of research as we have outstanding collaborators nearby who work on more applied aspects of plant biology, and can help us transfer this new knowledge into the field.'

Questions 27–32

Do the following statements agree with the information given in Reading Passage 3?

In boxes 27–32 on your answer sheet, write

TRUE	*if the statement agrees with the information*
FALSE	*if the statement contradicts the information*
NOT GIVEN	*if there is no information on this*

27 The Cambridge scientists' discovery of the 'thermometer molecule' caused surprise among other scientists.

28 The target for agricultural production by 2050 could be missed.

29 Wheat and rice suffer from a rise in temperatures.

30 It may be possible to develop crops that require less water.

31 Plants grow faster in sunlight than in shade.

32 Phytochromes change their state at the same speed day and night.

Questions 33–37

Reading Passage 3 has eight sections, **A–H**.

Which section contains the following information?

*Write the correct letter, **A–H**, in boxes 33–37 on your answer sheet.*

33 mention of specialists who can make use of the research findings

34 a reference to a potential benefit of the research findings

35 scientific support for a traditional saying

36 a reference to people traditionally making plans based on plant behaviour

37 a reference to where the research has been reported

Questions 38–40

Complete the sentences below.

Choose ***NO MORE THAN TWO WORDS*** *from the passage for each answer.*

Write your answers in boxes 38–40 on your answer sheet.

38 Daffodils are likely to flower early in response to ..... weather.

39 If ash trees come into leaf before oak trees, the weather in ..... will probably be wet.

40 The research was carried out using a particular species of ..... .

READING

READING PASSAGE 1

*You should spend about 20 minutes on **Questions 1–13**, which are based on Reading Passage 1 below.*

Roman tunnels

The Romans, who once controlled areas of Europe, North Africa and Asia Minor, adopted the construction techniques of other civilizations to build tunnels in their territories

The Persians, who lived in present-day Iran, were one of the first civilizations to build tunnels that provided a reliable supply of water to human settlements in dry areas. In the early first millennium BCE, they introduced the *qanat* method of tunnel construction, which consisted of placing posts over a hill in a straight line, to ensure that the tunnel kept to its route, and then digging vertical shafts down into the ground at regular intervals. Underground, workers removed the earth from between the ends of the shafts, creating a tunnel. The excavated soil was taken up to the surface using the shafts, which also provided ventilation during the work. Once the tunnel was completed, it allowed water to flow from the top of a hillside down towards a canal, which supplied water for human use. Remarkably, some *qanats* built by the Persians 2,700 years ago are still in use today.

They later passed on their knowledge to the Romans, who also used the *qanat* method to construct water-supply tunnels for agriculture. Roman *qanat* tunnels were constructed with vertical shafts dug at intervals of between 30 and 60 meters. The shafts were equipped with handholds and footholds to help those climbing in and out of them and were covered with a wooden or stone lid. To ensure that the shafts were vertical, Romans hung a plumb line from a rod placed across the top of each shaft and made sure that the weight at the end of it hung in the center of the shaft. Plumb lines were also used to measure the depth of the shaft and to determine the slope of the tunnel. The 5.6-kilometer-long Claudius tunnel, built in 41 CE to drain the Fucine Lake in central Italy, had shafts that were up to 122 meters deep, took 11 years to build and involved approximately 30,000 workers.

By the 6th century BCE, a second method of tunnel construction appeared called the *counter-excavation* method, in which the tunnel was constructed from both ends. It was used to cut through high mountains when the *qanat* method was not a practical alternative. This method required greater planning and advanced knowledge of surveying, mathematics and geometry as both ends of a tunnel had to meet correctly at the center of the mountain. Adjustments to the direction of the tunnel also had to be made whenever builders encountered geological problems or when it deviated from its set path. They constantly checked the tunnel's advancing direction,

for example, by looking back at the light that penetrated through the tunnel mouth, and made corrections whenever necessary. Large deviations could happen, and they could result in one end of the tunnel not being usable. An inscription written on the side of a 428-meter tunnel, built by the Romans as part of the Saldae aqueduct system in modern-day Algeria, describes how the two teams of builders missed each other in the mountain and how the later construction of a lateral link between both corridors corrected the initial error.

The Romans dug tunnels for their roads using the counter-excavation method, whenever they encountered obstacles such as hills or mountains that were too high for roads to pass over. An example is the 37-meter-long, 6-meter-high, Furlo Pass Tunnel built in Italy in 69–79 CE. Remarkably, a modern road still uses this tunnel today. Tunnels were also built for mineral extraction. Miners would locate a mineral vein and then pursue it with shafts and tunnels underground. Traces of such tunnels used to mine gold can still be found at the Dolaucothi mines in Wales. When the sole purpose of a tunnel was mineral extraction, construction required less planning, as the tunnel route was determined by the mineral vein.

Roman tunnel projects were carefully planned and carried out. The length of time it took to construct a tunnel depended on the method being used and the type of rock being excavated. The *qanat* construction method was usually faster than the counter-excavation method as it was more straightforward. This was because the mountain could be excavated not only from the tunnel mouths but also from shafts. The type of rock could also influence construction times. When the rock was hard, the Romans employed a technique called fire quenching which consisted of heating the rock with fire, and then suddenly cooling it with cold water so that it would crack. Progress through hard rock could be very slow, and it was not uncommon for tunnels to take years, if not decades, to be built. Construction marks left on a Roman tunnel in Bologna show that the rate of advance through solid rock was 30 centimeters per day. In contrast, the rate of advance of the Claudius tunnel can be calculated at 1.4 meters per day. Most tunnels had inscriptions showing the names of patrons who ordered construction and sometimes the name of the architect. For example, the 1.4-kilometer Çevlik tunnel in Turkey, built to divert the floodwater threatening the harbor of the ancient city of Seleuceia Pieria, had inscriptions on the entrance, still visible today, that also indicate that the tunnel was started in 69 CE and was completed in 81 CE.

Questions 1–6

Label the diagrams below.

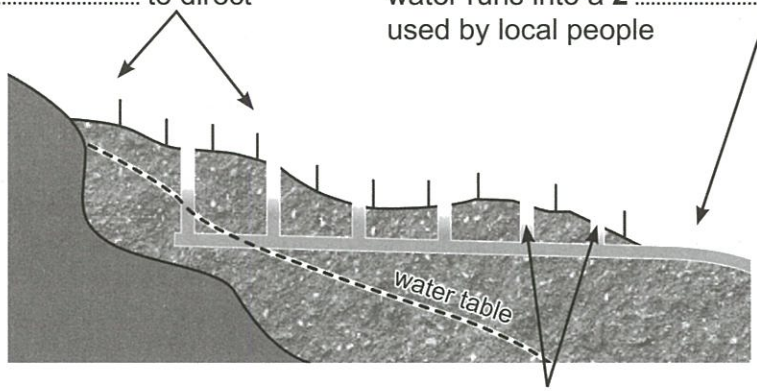
*Choose **ONE WORD ONLY** from the passage for each answer.*

Write your answers in boxes 1–6 on your answer sheet.

The Persian Qanat Method

1 ..... to direct the tunnelling

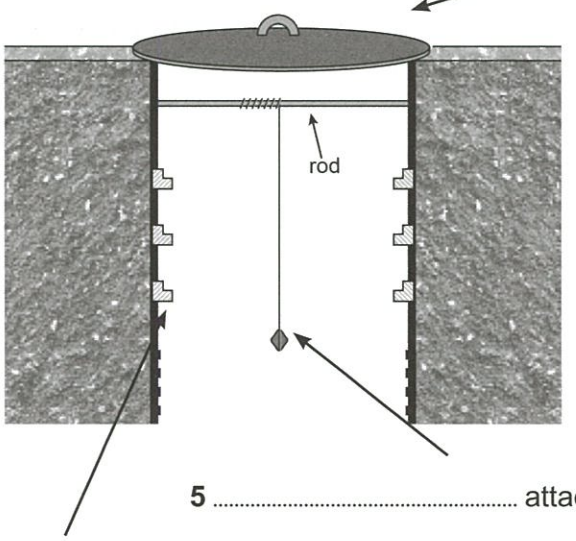
water runs into a **2** ..... used by local people



vertical shafts to remove earth and for **3** .....

Cross-section of a Roman Qanat Shaft

4 ..... made of wood or stone



5 ..... attached to the plumb line

handholds and footholds used for **6** .....

Questions 7–10

Do the following statements agree with the information given in Reading Passage 1?

In boxes 7–10 on your answer sheet, write

TRUE	*if the statement agrees with the information*
FALSE	*if the statement contradicts the information*
NOT GIVEN	*if there is no information on this*

7 The counter-excavation method completely replaced the qanat method in the 6th century BCE.

8 Only experienced builders were employed to construct a tunnel using the counter-excavation method.

9 The information about a problem that occurred during the construction of the Saldae aqueduct system was found in an ancient book.

10 The mistake made by the builders of the Saldae aqueduct system was that the two parts of the tunnel failed to meet.

Questions 11–13

Answer the questions below.

*Choose **NO MORE THAN TWO WORDS** from the passage for each answer.*

Write your answers in boxes 11–13 on your answer sheet.

11 What type of mineral were the Dolaucothi mines in Wales built to extract?

12 In addition to the patron, whose name might be carved onto a tunnel?

13 What part of Seleuceia Pieria was the Çevlik tunnel built to protect?

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READING PASSAGE 2

*You should spend about 20 minutes on **Questions 14–26**, which are based on Reading Passage 2 below.*

Changes in reading habits

What are the implications of the way we read today?

Look around on your next plane trip. The iPad is the new pacifier for babies and toddlers. Younger school-aged children read stories on smartphones; older kids don't read at all, but hunch over video games. Parents and other passengers read on tablets or skim a flotilla of email and news feeds. Unbeknown to most of us, an invisible, game-changing transformation links everyone in this picture: the neuronal circuit that underlies the brain's ability to read is subtly, rapidly changing and this has implications for everyone from the pre-reading toddler to the expert adult.

As work in neurosciences indicates, the acquisition of literacy necessitated a new circuit in our species' brain more than 6,000 years ago. That circuit evolved from a very simple mechanism for decoding basic information, like the number of goats in one's herd, to the present, highly elaborated reading brain. My research depicts how the present reading brain enables the development of some of our most important intellectual and affective processes: internalized knowledge, analogical reasoning, and inference; perspective-taking and empathy; critical analysis and the generation of insight. Research surfacing in many parts of the world now cautions that each of these essential 'deep reading' processes may be under threat as we move into digital-based modes of reading.

This is not a simple, binary issue of print versus digital reading and technological innovation. As MIT scholar Sherry Turkle has written, we do not err as a society when we innovate but when we ignore what we disrupt or diminish while innovating. In this hinge moment between print and digital cultures, society needs to confront what is diminishing in the expert reading circuit, what our children and older students are not developing, and what we can do about it.

We know from research that the reading circuit is not given to human beings through a genetic blueprint like vision or language; it needs an environment to develop. Further, it will adapt to that environment's requirements – from different writing systems to the characteristics of whatever medium is used. If the dominant medium advantages processes that are fast, multi-task oriented and well-suited for large volumes of information, like the current digital medium, so will the reading circuit. As UCLA psychologist Patricia Greenfield writes, the result is that less attention and time will be allocated to slower, time-demanding deep reading processes.

Increasing reports from educators and from researchers in psychology and the humanities bear this out. English literature scholar and teacher Mark Edmundson describes how many college students actively avoid the classic literature of the 19th and 20th centuries in favour of something simpler as they no longer have the patience to read longer, denser, more difficult texts. We should

be less concerned with students' 'cognitive impatience', however, than by what may underlie it: the potential inability of large numbers of students to read with a level of critical analysis sufficient to comprehend the complexity of thought and argument found in more demanding texts.

Multiple studies show that digital screen use may be causing a variety of troubling downstream effects on reading comprehension in older high school and college students. In Stavanger, Norway, psychologist Anne Mangen and her colleagues studied how high school students comprehend the same material in different mediums. Mangen's group asked subjects questions about a short story whose plot had universal student appeal; half of the students read the story on a tablet, the other half in paperback. Results indicated that students who read on print were superior in their comprehension to screen-reading peers, particularly in their ability to sequence detail and reconstruct the plot in chronological order.

Ziming Liu from San Jose State University has conducted a series of studies which indicate that the 'new norm' in reading is skimming, involving word-spotting and browsing through the text. Many readers now use a pattern when reading in which they sample the first line and then word-spot through the rest of the text. When the reading brain skims like this, it reduces time allocated to deep reading processes. In other words, we don't have time to grasp complexity, to understand another's feelings, to perceive beauty, and to create thoughts of the reader's own.

The possibility that critical analysis, empathy and other deep reading processes could become the unintended 'collateral damage' of our digital culture is not a straightforward binary issue about print versus digital reading. It is about how we all have begun to read on various mediums and how that changes not only what we read, but also the purposes for which we read. Nor is it only about the young. The subtle atrophy of critical analysis and empathy affects us all equally. It affects our ability to navigate a constant bombardment of information. It incentivizes a retreat to the most familiar stores of unchecked information, which require and receive no analysis, leaving us susceptible to false information and irrational ideas.

There's an old rule in neuroscience that does not alter with age: use it or lose it. It is a very hopeful principle when applied to critical thought in the reading brain because it implies choice. The story of the changing reading brain is hardly finished. We possess both the science and the technology to identify and redress the changes in how we read before they become entrenched. If we work to understand exactly what we will lose, alongside the extraordinary new capacities that the digital world has brought us, there is as much reason for excitement as caution.

Questions 14–17

*Choose the correct letter, **A**, **B**, **C** or **D**.*

Write the correct letter in boxes 14–17 on your answer sheet.

14 What is the writer's main point in the first paragraph?

A Our use of technology is having a hidden effect on us.
B Technology can be used to help youngsters to read.
C Travellers should be encouraged to use technology on planes.
D Playing games is a more popular use of technology than reading.

15 What main point does Sherry Turkle make about innovation?

A Technological innovation has led to a reduction in print reading.
B We should pay attention to what might be lost when innovation occurs.
C We should encourage more young people to become involved in innovation.
D There is a difference between developing products and developing ideas.

16 What point is the writer making in the fourth paragraph?

A Humans have an inborn ability to read and write.
B Reading can be done using many different mediums.
C Writing systems make unexpected demands on the brain.
D Some brain circuits adjust to whatever is required of them.

17 According to Mark Edmundson, the attitude of college students

A has changed the way he teaches.
B has influenced what they select to read.
C does not worry him as much as it does others.
D does not match the views of the general public.

Questions 18–22

Complete the summary using the list of words, ***A–H****, below.*

Write the correct letter, ***A–H****, in boxes 18–22 on your answer sheet.*

Studies on digital screen use

There have been many studies on digital screen use, showing some **18** ..... trends. Psychologist Anne Mangen gave high-school students a short story to read, half using digital and half using print mediums. Her team then used a question-and-answer technique to find out how **19** ..... each group's understanding of the plot was. The findings showed a clear pattern in the responses, with those who read screens finding the order of information **20** ..... to recall.

Studies by Ziming Liu show that students are tending to read **21** ..... words and phrases in a text to save time. This approach, she says, gives the reader a superficial understanding of the **22** ..... content of material, leaving no time for thought.

A	fast	**B**	isolated	**C**	emotional	**D**	worrying
E	many	**F**	hard	**G**	combined	**H**	thorough

Questions 23–26

Do the following statements agree with the views of the writer in Reading Passage 2?

In boxes 23–26 on your answer sheet, write

YES	*if the statement agrees with the views of the writer*
NO	*if the statement contradicts the views of the writer*
NOT GIVEN	*if it is impossible to say what the writer thinks about this*

23 The medium we use to read can affect our choice of reading content.

24 Some age groups are more likely to lose their complex reading skills than others.

25 False information has become more widespread in today's digital era.

26 We still have opportunities to rectify the problems that technology is presenting.

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READING PASSAGE 3

*You should spend about 20 minutes on **Questions 27–40**, which are based on Reading Passage 3 on pages 91 and 92.*

Questions 27–32

Reading Passage 3 has six sections, **A–F**.

Choose the correct heading for each section from the list of headings below.

*Write the correct number, **i–viii**, in boxes 27–32 on your answer sheet.*

List of Headings

- **i** An increasing divergence of attitudes towards AI
- **ii** Reasons why we have more faith in human judgement than in AI
- **iii** The superiority of AI projections over those made by humans
- **iv** The process by which AI can help us make good decisions
- **v** The advantages of involving users in AI processes
- **vi** Widespread distrust of an AI innovation
- **vii** Encouraging openness about how AI functions
- **viii** A surprisingly successful AI application

27 Section **A**

28 Section **B**

29 Section **C**

30 Section **D**

31 Section **E**

32 Section **F**

Attitudes towards Artificial Intelligence

A Artificial intelligence (AI) can already predict the future. Police forces are using it to map when and where crime is likely to occur. Doctors can use it to predict when a patient is most likely to have a heart attack or stroke. Researchers are even trying to give AI imagination so it can plan for unexpected consequences.

Many decisions in our lives require a good forecast, and AI is almost always better at forecasting than we are. Yet for all these technological advances, we still seem to deeply lack confidence in AI predictions. Recent cases show that people don't like relying on AI and prefer to trust human experts, even if these experts are wrong.

If we want AI to really benefit people, we need to find a way to get people to trust it. To do that, we need to understand why people are so reluctant to trust AI in the first place.

B Take the case of Watson for Oncology, one of technology giant IBM's supercomputer programs. Their attempt to promote this program to cancer doctors was a PR disaster. The AI promised to deliver top-quality recommendations on the treatment of 12 cancers that accounted for 80% of the world's cases. But when doctors first interacted with Watson, they found themselves in a rather difficult situation. On the one hand, if Watson provided guidance about a treatment that coincided with their own opinions, physicians did not see much point in Watson's recommendations. The supercomputer was simply telling them what they already knew, and these recommendations did not change the actual treatment.

On the other hand, if Watson generated a recommendation that contradicted the experts' opinion, doctors would typically conclude that Watson wasn't competent. And the machine wouldn't be able to explain why its treatment was plausible because its machine-learning algorithms were simply too complex to be fully understood by humans. Consequently, this has caused even more suspicion and disbelief, leading many doctors to ignore the seemingly outlandish AI recommendations and stick to their own expertise.

C This is just one example of people's lack of confidence in AI and their reluctance to accept what AI has to offer. Trust in other people is often based on our understanding of how others think and having experience of their reliability. This helps create a psychological feeling of safety. AI, on the other hand, is still fairly new and unfamiliar to most people. Even if it can be technically explained (and that's not always the case), AI's decision-making process is usually too difficult for most people to comprehend. And interacting with something we don't understand can cause anxiety and give us a sense that we're losing control.

Many people are also simply not familiar with many instances of AI actually working, because it often happens in the background. Instead, they are acutely aware of instances where AI goes wrong. Embarrassing AI failures receive a disproportionate amount of media attention, emphasising the message that we cannot rely on technology. Machine learning is not foolproof, in part because the humans who design it aren't.

D Feelings about AI run deep. In a recent experiment, people from a range of backgrounds were given various sci-fi films about AI to watch and then asked questions about automation in everyday life. It was found that, regardless of whether the film they watched depicted AI in a positive or negative light, simply watching a cinematic vision of our technological future polarised the participants' attitudes. Optimists became more extreme in their enthusiasm for AI and sceptics became even more guarded.

This suggests people use relevant evidence about AI in a biased manner to support their existing attitudes, a deep-rooted human tendency known as "confirmation bias". As AI is represented more and more in media and entertainment, it could lead to a society split between those who benefit from AI and those who reject it. More pertinently, refusing to accept the advantages offered by AI could place a large group of people at a serious disadvantage.

E Fortunately, we already have some ideas about how to improve trust in AI. Simply having previous experience with AI can significantly improve people's opinions about the technology, as was found in the study mentioned above. Evidence also suggests the more you use other technologies such as the internet, the more you trust them.

Another solution may be to reveal more about the algorithms which AI uses and the purposes they serve. Several high-profile social media companies and online marketplaces already release transparency reports about government requests and surveillance disclosures. A similar practice for AI could help people have a better understanding of the way algorithmic decisions are made.

F Research suggests that allowing people some control over AI decision-making could also improve trust and enable AI to learn from human experience. For example, one study showed that when people were allowed the freedom to slightly modify an algorithm, they felt more satisfied with its decisions, more likely to believe it was superior and more likely to use it in the future.

We don't need to understand the intricate inner workings of AI systems, but if people are given a degree of responsibility for how they are implemented, they will be more willing to accept AI into their lives.

Questions 33–35

*Choose the correct letter, **A**, **B**, **C** or **D**.*

Write the correct letter in boxes 33–35 on your answer sheet.

33 What is the writer doing in Section A?

A providing a solution to a concern
B justifying an opinion about an issue
C highlighting the existence of a problem
D explaining the reasons for a phenomenon

34 According to Section C, why might some people be reluctant to accept AI?

A They are afraid it will replace humans in decision-making jobs.
B Its complexity makes them feel that they are at a disadvantage.
C They would rather wait for the technology to be tested over a period of time.
D Misunderstandings about how it works make it seem more challenging than it is.

35 What does the writer say about the media in Section C of the text?

A It leads the public to be mistrustful of AI.
B It devotes an excessive amount of attention to AI.
C Its reports of incidents involving AI are often inaccurate.
D It gives the impression that AI failures are due to designer error.

Questions 36–40

Do the following statements agree with the claims of the writer in Reading Passage 3?

In boxes 36–40 on your answer sheet, write

YES	*if the statement agrees with the claims of the writer*
NO	*if the statement contradicts the claims of the writer*
NOT GIVEN	*if it is impossible to say what the writer thinks about this*

36 Subjective depictions of AI in sci-fi films make people change their opinions about automation.

37 Portrayals of AI in media and entertainment are likely to become more positive.

38 Rejection of the possibilities of AI may have a negative effect on many people's lives.

39 Familiarity with AI has very little impact on people's attitudes to the technology.

40 AI applications which users are able to modify are more likely to gain consumer approval.

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