

Academic Reading Paper 02

Tunnels, Tree Rings and Targets

Time allowed: 1 hour

INSTRUCTIONS TO CANDIDATES

- Do not open this booklet until you are told to do so.
- Write your name and the date at the top of the answer sheet.
- Answer **all** the questions.
- Write your answers **on the answer sheet**, not in this booklet.
- You must transfer your answers within the hour. **No extra time is given for transferring answers in the Reading test.**
- Do not remove this booklet from the examination room.

INFORMATION FOR CANDIDATES

- There are 40 questions in this paper.
- Each question carries one mark.
- There are three passages, with 13, 13 and 14 questions.

These passages were written for this library. They are **not** reproduced from any published past paper. The format, timing and task types follow the published specification for the Academic Reading test so that sitting this on paper feels like the real thing.

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

The qanat

For at least twenty-five centuries a large part of the Iranian plateau has been watered by tunnels. A qanat is a gently sloping channel driven underground from a water-bearing layer in the gravels at the foot of the mountains to a village or a field on the plain below. It has no pump and no moving part of any kind. The water arrives because the tunnel falls a little more steeply than the water table it started in, and it stops arriving when the two lines cross. Nothing about the design has changed in a very long time.

Work begins with a trial shaft, the mother well, sunk where the diggers expect to strike water. If the shaft fills and holds, its depth is recorded and the line to the village is set out on the surface. The channel itself — the gallery — is then driven from the village end inland, and as it advances a series of access shafts is sunk from above to meet it. They ventilate the workings, bring out the spoil and, above all, keep the tunnel straight: a digger a hundred metres underground has nothing else to steer by.

The gradient is the difficult part. Too gentle and the water stands and silts the channel up; too steep and the current scours the floor, undercuts the walls and in time brings the roof down. In practice the floor is made to fall by about one metre in every thousand, a slope no eye can detect, held by measurement over distances of several kilometres. Where the ground is loose the tunnel is lined with hoops of baked clay, set one against the next like the sections of a pipe, and it is the failure of these that most often closes an old qanat.

Setting out the line called for instruments a modern surveyor would recognise as ancestors of his own. A plumb line dropped down each shaft gave the vertical; a water level and a knotted cord carried the fall from one shaft to the next; and the alignment was checked by hanging two lamps in the tunnel and sighting along them, so that a digger working in the dark could tell whether he had drifted. Errors were found and corrected shaft by shaft, which is why a qanat that wanders across the surface still runs true underground.

The digging was done by a small hereditary profession, the muqanni, who were paid well and died early. A gallery is about a metre and a quarter high and rather less than a metre wide — sized for one man crouching — and its two hazards, collapse and drowning, arrive without notice. Villages kept their qanat in repair by a levy on the households that drew from it.

The scale is not obvious from the surface, where a qanat shows only as a line of low earth rings running across otherwise empty country. Some thirty-six thousand qanats have been recorded in Iran. The system at Gonabad, which is about two and a half thousand years old, runs for thirty-three kilometres and has a mother well roughly three hundred metres deep, the deepest known.

The technique travelled. It reached Oman, where the same works are called aflaj, and the oases of the Sahara, where they are foggaras; it went with Islamic rule into Spain, and from Spain, in the sixteenth century, to Mexico and Peru. Everywhere it went it carried its law with it. Because the flow of a qanat cannot be turned off or stored, a share in one is expressed as a length of time — so many hours of the channel, on a rotation of so many days — rather than as a quantity of water. Rights of that kind can be inherited, sold and mortgaged, and in parts of Iran they still are.

What has undone the qanat is not neglect but competition. A diesel or electric pump can lift water from a depth no gallery can reach, and at whatever rate its owner chooses. Tube wells spread across the plateau from the middle of the twentieth century, the water table fell beneath the mouths of the old galleries, and systems that had run for two thousand years went dry within a generation. Iran's surviving qanats were placed on the UNESCO World Heritage list in 2016. The listing protects a technology whose chief virtue is now easy to see and hard to reproduce: a qanat cannot take more water than the aquifer yields, because the gravity that delivers the water also limits it.

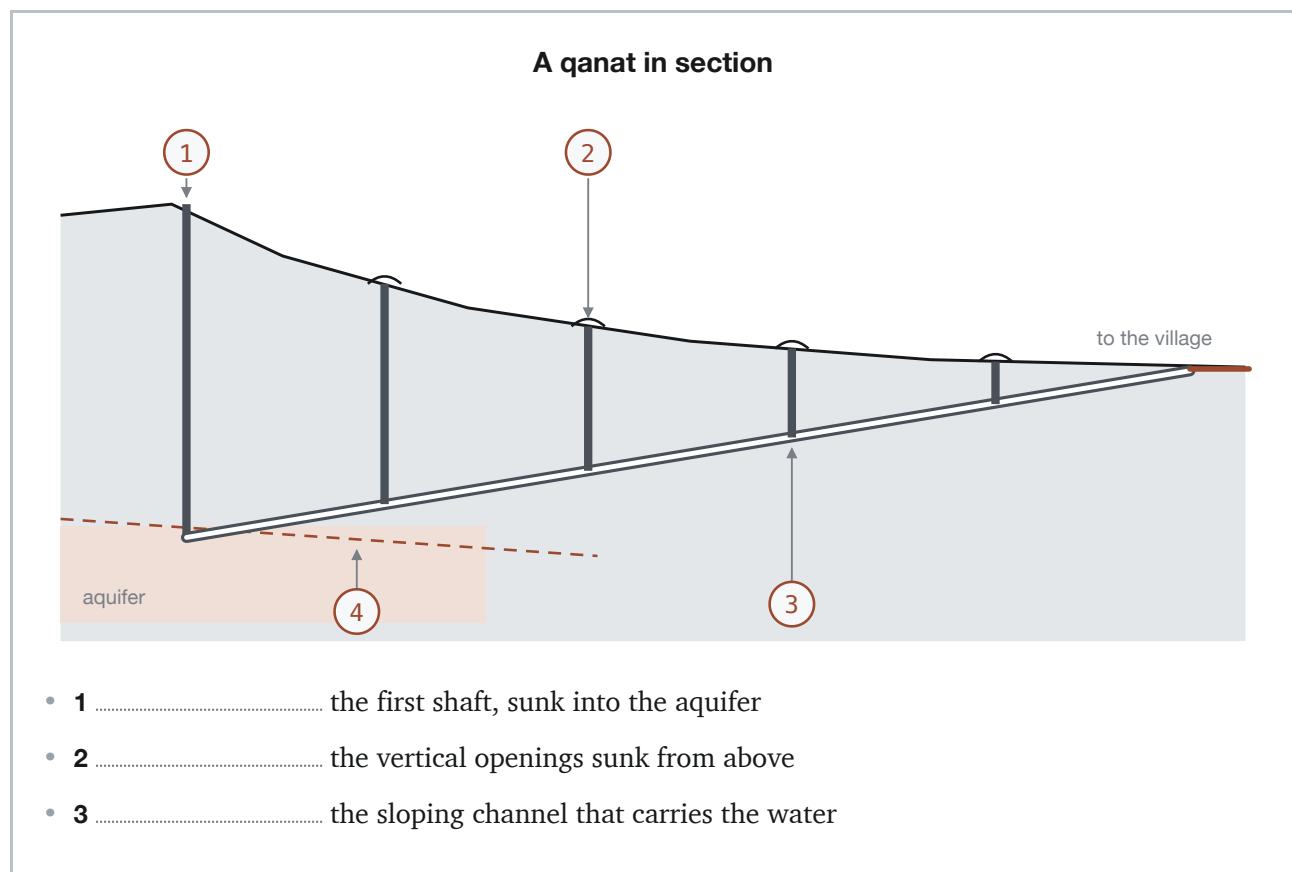
aquifer: a layer of rock or gravel that holds groundwater

spoil: earth and rock removed during digging

Questions 1–4

Label the diagram below.

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



- 4 the level the tunnel starts from and must fall below

Questions 5–8

Answer the questions below.

Choose **NO MORE THAN THREE WORDS AND/OR A NUMBER** from the passage for each answer.

- 5 What were the men who dug qanats called?
- 6 What are the hoops used to line unstable ground made of?
- 7 How deep is the mother well at Gonabad?
- 8 What caused the water table to fall below the old galleries?

Questions 9–13

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

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

- 9 The qanat at Gonabad is the longest in Iran.
- 10 The gallery is dug before the mother well is sunk.
- 11 Iran has more qanats than any other country.
- 12 A share in a qanat is defined as a fixed quantity of water.
- 13 A qanat cannot draw more water than its aquifer produces.

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

Reading the tree rings

The idea that a tree keeps a record of the weather is old and obvious. The idea that the record can be read to a single year, in a piece of wood whose age nobody knows, is neither, and it arrived by an unlikely route. In 1901 Andrew Ellicott Douglass, an astronomer working in Arizona, was looking for evidence of an eleven-year sunspot cycle in the climate of the American south-west. Instruments had been kept for a few decades at best. Trees, he reasoned, had been keeping them for centuries.

A tree in a temperate or arid climate lays down one ring a year: a band of large, pale cells in spring, a band of small, dark ones as growth slows. The width of the ring is set by whatever the tree is short of. On a dry site the limiting factor is moisture, and a wide ring means a wet year; at the upper limit of the tree-line it is warmth, and a wide ring means a warm summer. This is the first thing a student of the subject has to unlearn — that wide means good. It means only that the scarce thing was less scarce than usual.

Douglass's decisive step was cross-dating. Because the trees of a region share their weather they share the pattern of wide and narrow rings, and the pattern is irregular enough to be unique over a run of forty or fifty years, in the way that a stretch of a fingerprint is. A sequence measured in a living tree can therefore be matched against a sequence measured in a dead one whose outer rings overlap it, and that one against an older piece still. By working backwards through beams taken from old buildings, and then through trunks buried in river gravels, a master chronology is assembled that reaches far behind any living tree. Douglass founded the Laboratory of Tree-Ring Research at the University of Arizona in 1937 to do this systematically.

The technique itself is undramatic. A hollow bit called an increment borer is turned into the trunk at chest height and withdrawn holding a pencil-thick core; the tree seals the wound. The core is dried, glued into a grooved mount and sanded, sometimes to a polish, until the cell boundaries stand out under a microscope. Ring widths are then measured to a hundredth of a millimetre and plotted, and the plot is compared with the master chronology until it locks into position. Where it locks, the outermost ring has a calendar year, and so does every ring behind it.

The chronologies grew long. Wesley Ferguson, working in the White Mountains of California, extended the American sequence past eight thousand years using the bristlecone pine, a tree that grows slowly, dies slowly and rots hardly at all. In Germany, Bernd Becker built an oak chronology of comparable depth from trunks dredged out of the gravels of the Rhine, the Main and the Danube, timber that had lain in wet ground since the last ice age.

It was at this point that dendrochronology stopped being a specialism and became a problem for everybody else. Radiocarbon dating assumes that the proportion of carbon-14 in the atmosphere has been constant. Hans Suess, at La Jolla, measured the carbon-14 in tree rings of known calendar age and

showed that it has not: the proportion has wandered, and the wander is large enough to matter. Because the drift runs one way over the relevant range, uncalibrated radiocarbon dates for the more distant past come out too young, and the error grows with age.

The consequences were felt hardest in European prehistory. The accepted account had the great stone monuments of western Europe descending from Mediterranean and Near Eastern models, on the reasonable ground that the eastern structures were older. With the calibration applied, they were not. Colin Renfrew argued in the early 1970s that the sequence had been inverted, that the monuments of Brittany and the British Isles preceded the ones they were supposed to imitate, and that a whole architecture of borrowed influence had to be dismantled. The dates that did the dismantling had been read off tree rings.

The method has limits and they are worth stating. It works only where trees make one clear ring a year, and in the wet tropics many do not. It dates the wood and not the building, so a beam taken from an older structure and re-used will date the older structure. And a chronology is regional: a sequence built on Arizonan pines will not date an Irish oak. What it offers within those limits is something almost nothing else in the study of the past can offer — a date in a calendar year, with no error term at all, from a piece of wood.

Questions 14–18

Complete the flow-chart below.

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

Dating a piece of wood
A pencil-thick core is taken from the trunk with an 14
↓
The core is dried, mounted and 15 until the cells are visible.
↓
Ring widths are measured to a 16 of a millimetre and plotted.
↓
The plot is compared with the 17 until it locks into position.
↓
Every ring in the sample is given a 18

Questions 19–23

Look at the following statements and the list of researchers below.

Match each statement with the correct researcher, A–E.

NB You may use any letter more than once.

List of Researchers

- A** Andrew Ellicott Douglass
- B** Wesley Ferguson
- C** Hans Suess
- D** Bernd Becker
- E** Colin Renfrew

- 19** He took up the study of tree rings in the course of research on the sun.
- 20** He used a species that decays extremely slowly to lengthen a chronology.
- 21** He showed that an assumption underlying another dating method was false.
- 22** He built a chronology from timber recovered from wet ground.
- 23** He argued that an accepted direction of influence had to be reversed.

Questions 24–26

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

- 24** The Laboratory of Tree-Ring Research
 - A** was established in 1901.
 - B** was established in 1937.
 - C** was set up in order to calibrate radiocarbon dates.
 - D** was founded by Wesley Ferguson.
- 25** According to the passage, a wide ring shows that
 - A** the tree was in good health that year.
 - B** rainfall was above average that year.
 - C** whatever the tree most lacked was less scarce than usual.
 - D** the summer was warmer than usual.

- 26** Suess's work showed that uncalibrated radiocarbon dates for the distant past were
- A** too old.
 - B** too young.
 - C** reliable only for European material.
 - D** unusable beyond eight thousand years.

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

The measure that changes what it measures

In 1975 Charles Goodhart, then an adviser at the Bank of England, made a remark in a conference paper on monetary policy that has since escaped its subject entirely. Any observed statistical regularity, he wrote, will tend to collapse once pressure is placed upon it for control purposes. He meant something narrow: that the relationships between money-supply measures which the Bank had observed while merely watching them would not survive the Bank's beginning to steer by them. He was right about that. The wider claim he is now credited with, he did not make.

The sentence everyone quotes — when a measure becomes a target, it ceases to be a good measure — was written twenty-two years later by the anthropologist Marilyn Strathern, in an essay on the audit of British universities. It is a compression rather than a quotation, and it is a better sentence than the one it compresses, which is why it has displaced it. Something similar was said a year after Goodhart by the psychologist Donald Campbell, in a formulation blunter about the mechanism: the more heavily a quantitative indicator is used for social decision-making, the more it will distort and corrupt the processes it was meant to monitor.

Campbell's version is the useful one, because it names two different failures and most arguments about metrics confuse them. The first is gaming: the measured party finds a cheaper way to move the number than the way that was intended. A hospital judged on how long patients wait in the emergency department can employ another doctor, or it can hold the ambulances outside the door until a bed is free, and the second is quicker. The second failure is subtler and worse. It is that the measured party comes, in good faith, to believe that the number is the thing. A school judged on the proportion of pupils reaching a threshold grade will concentrate on the pupils just below it, not because anyone is cheating but because that is where the marks are; the pupils far below the line, who need the teaching most, become invisible to the institution that is teaching them.

At this point the argument usually swings too far, and it is worth stopping it. The alternative to measurement is not judgement; it is unaccountable judgement, and the historical record of that is poor. When surgical mortality figures were first published by name in New York State, the surgeons objected, and outcomes improved. Publishing the rate at which hospitals acquired infections reduced infections. The demand that an institution show its working is a democratic demand, and it is answered in numbers because numbers can be checked by people who were not in the room. Anyone who argues that measurement corrupts should be asked what they propose to put in its place, and held to the answer.

The problem, then, is not measurement. It is a particular way of using a measurement: attaching a heavy consequence to a single indicator and then reading the indicator as though the consequence were not attached. A number produced under no pressure describes something. The same number, once a career or

a budget depends on it, is no longer a description but a performance, and it should be read as one. Almost everything that goes wrong in this field follows from forgetting which of the two is in front of you.

Three things follow, none of them radical. The first is that indicators should be used in bundles that pull against one another, so that the cheap way of moving one of them shows up as damage in another: waiting times beside re-admission rates, examination results beside what becomes of the pupils who were furthest behind. A single number can be gamed in isolation; a set containing its own contradictions is much harder to game quietly.

The second is that a measure should be retired, or at least re-based, once it has been used long enough to have shaped the behaviour it describes. Regularities decay under pressure — this was Goodhart's actual point — and an indicator that has been steered by for a decade is measuring the steering.

The third is the least popular. Somebody must keep the authority to say that the number is wrong in this case, and must answer for saying so. Every scheme for removing discretion from the reading of indicators ends by relocating the discretion somewhere less visible: into the choice of indicator, into the definition of the threshold, into the decision about which data are gathered at all. Discretion cannot be abolished. It can only be put where someone can be asked about it.

None of this is an argument for governing by intuition, and none of it says that the people who build indicators are dishonest; most of the damage in this field is done in good faith, with a number that has stopped being interrogated. The claim is narrower. A measure is a description of the world made under particular conditions, and one of those conditions is that nobody was trying to move it. Change that condition and you have changed the instrument, whatever the reading still says.

Questions 27–32

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

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

- 27** The sentence usually quoted as Goodhart's law was written by Goodhart.
- 28** Campbell's formulation appeared before Goodhart's remark.
- 29** The writer considers Strathern's sentence better than the one it compresses.
- 30** Publishing infection rates had a greater effect than publishing surgical mortality figures.
- 31** Holding ambulances outside is more common than employing an extra doctor.
- 32** The writer regards it as impossible to take discretion out of the use of indicators.

Questions 33–37

Complete each sentence with the correct ending, A–H, below.

Endings

- A concerned the behaviour of monetary statistics once they were used for control.
- B distinguishes two different ways in which an indicator can go wrong.
- C can happen without anybody intending to cheat.
- D makes the cheap way of moving one number show up as harm in another.
- E only moves it somewhere harder to see.
- F has been shown to work only in health care.
- G proves that published figures never change behaviour.
- H was withdrawn by its author.

- 33 Goodhart's remark of 1975
- 34 Campbell's formulation
- 35 Concentrating on the pupils just below a threshold grade
- 36 Using indicators in bundles
- 37 Any attempt to remove discretion from the reading of indicators

Questions 38–40

Complete the sentences below.

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

- 38 Goodhart's remark of 1975 was made in a conference paper on policy.
- 39 Once a career or a budget depends on it, a number stops being a description and becomes a
- 40 An indicator that has been steered by for ten years is, in the writer's phrase, measuring the