

Academic Reading Paper 27

Metres, Neurons and Slack

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 definition that could not be wrong

In 1791 the French Academy of Sciences decided that the new unit of length should be derived from the planet rather than from a king, and defined the metre as one ten-millionth of the distance from the North Pole to the equator along the line of longitude passing through Paris. This was a political decision as much as a scientific one. A unit taken from the Earth belonged to nobody and could in principle be recovered by anyone, which was the point of it in a country that had just abolished the authority under which its old measures had been issued.

Somebody then had to measure that distance. Jean-Baptiste Delambre and Pierre Méchain were sent out from Paris in opposite directions, one north to Dunkirk and the other south to Barcelona, to survey the arc between them by triangulation: fixing a chain of triangles from hilltop to hilltop, measuring the angles of each, and measuring a single baseline on flat ground to give the whole chain its scale. The work was expected to take a year. It took seven, through a revolution and a war, with both men repeatedly arrested as suspicious persons carrying instruments up hills.

Méchain, at the southern end, obtained two determinations of the latitude of Barcelona that did not agree. The difference was small and it should not have existed, and he did not report it. He spent the rest of his life attempting to construct a set of observations that would remove the discrepancy without admitting it, and died of fever in 1804 while extending the survey in the hope of doing so. The discrepancy was later shown to have been largely real: local rock deflects a plumb line slightly from the vertical, so a latitude fixed against the stars is measured from a reference that is not quite where it should be.

The metre that came out of the survey is about a fifth of a millimetre short of the definition it was meant to embody, because the Earth is a little flatter than the calculation assumed. This mattered less than it sounds, because what was made in 1799 was not a formula but a bar of platinum, and the bar was thereafter the metre. The definition had quietly changed from a statement about the planet to a statement about an object in a vault in Paris, and everybody involved knew it and thought it a reasonable exchange.

That arrangement was formalised in 1875, when seventeen states signed a convention and commissioned new prototypes of an alloy of platinum and iridium, cast with an X-shaped cross-section so that they would sag as little as possible under their own weight. Copies were distributed to the signatory countries in 1889. The kilogram received the same treatment: a cylinder of the same alloy, kept at Sèvres under three glass bell jars, with six official copies beside it and further copies abroad.

The trouble with defining a unit as an object is not that the object might be destroyed. It is subtler and it took a century to become visible. When the prototype kilogram and its copies were compared, which happened roughly every forty years, they were found to have drifted apart by something in the region of

fifty micrograms. Nobody could say which of them had changed, and the question was not merely difficult; it was meaningless. The prototype weighed one kilogram by definition, so if it gained mass the world got lighter.

Length escaped first. In 1960 the metre was redefined in terms of the wavelength of a particular orange line in the spectrum of krypton, which is a property of an atom rather than of a manufactured thing, and any laboratory with the right equipment could reproduce it. In 1983 it was redefined again and more elegantly: the speed of light was fixed by decree at exactly two hundred and ninety-nine million, seven hundred and ninety-two thousand, four hundred and fifty-eight metres per second, and the metre became whatever distance light covers in that fraction of a second. Length is now defined by time.

Mass held out until 2019, because there was no comparably precise way to connect a kilogram to anything fundamental. The instrument that eventually did it, the Kibble balance, opposes the weight of a mass with a magnetic force whose strength is determined by electrical measurements, so that a mass can be weighed against quantities that are known in terms of the Planck constant. Fixing that constant by decree redefined the kilogram, and the cylinder at Sèvres, which had been the definition of mass for a hundred and thirty years, became an ordinary and rather good weight. Every base unit is now fixed to a constant of nature, and none of them depends on any object that could be dropped.

Questions 1–5

Complete the table below.

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

What the metre was defined by		
From	The definition	What it depended on
1791	one ten-millionth of the distance from the pole to the equator, along the line of longitude through 1	a measurement of the planet
1799	a bar of 2 kept in Paris	one object
1875	prototypes with an 3 cross-section, to sag as little as possible	one object, with copies
1960	the wavelength of an orange line in the spectrum of 4	a property of an atom
1983	the distance light travels in a fixed fraction of a 5	a fixed constant, and time

Questions 6–9

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.

- 6 The survey took considerably longer than had been expected.
- 7 Méchain's disagreeing measurements were the result of his own carelessness.
- 8 The 1799 platinum bar was made to a length the surveyors knew to be slightly wrong.
- 9 When the prototype kilogram drifted, it was possible to establish which object had changed.

Questions 10–13

Complete the sentences below.

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

- 10 The two surveyors fixed a chain of triangles from hilltop to hilltop and measured a single on flat ground to give the chain its scale.
- 11 The prototype kilogram and its copies were compared roughly every years.
- 12 The kilogram was not redefined until , because no precise link to anything fundamental existed.
- 13 The Kibble balance opposes the weight of a mass with a force measured electrically.

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

One net or many cells

- A** Every organ that had been examined under a microscope by 1870 turned out to be made of separate cells. The brain appeared to be the exception. Nervous tissue under the instruments of the time was an impenetrable felt of overlapping fibres in which nothing could be traced from one end to the other, and the reasonable conclusion, held by most of the people best placed to judge, was that the nervous system was a continuous network: a single branching structure through which excitation flowed as water flows through pipes. This was not stubbornness. It was what the tissue looked like, and it had the additional attraction of explaining how a signal could get anywhere without being interrupted.
- B** The method that made the question answerable was found by accident and by a man working in a converted kitchen. Camillo Golgi, in 1873, discovered that tissue left in a solution of potassium dichromate and then treated with silver nitrate develops a black deposit inside a small and apparently random fraction of the cells, perhaps one in a hundred, and stains those completely, from the body of the cell out to the ends of its finest branches. Everything else stays transparent, so that a single cell appears complete and isolated against a clear background, as though it had been lifted out of the tissue and drawn. The problem had never been that the cells were too small to see. It was that staining them all was the same as staining none, since a picture in which everything is black contains no information about what connects to what. Why the method picks the cells it picks is still not fully understood.
- C** Golgi looked at what his own method revealed and concluded that he had been right about the network. He could follow a fibre a long way and see it branch and mingle with others, and where two branches met he could not see a gap, so he inferred that there was none. It is worth being exact about what this reasoning was: an argument from the absence of a feature at the limit of the instrument's resolution. Such an argument is not worthless, but it is only as strong as the instrument, and Golgi went on making it for three decades after better arguments had appeared.
- D** Santiago Ramón y Cajal took up the same method in Spain a decade later and drew the opposite conclusion from the same pictures. His argument was not that he could see gaps, because he could not. It was that the branches of one cell consistently ended near another cell without ever being traceable into it, that the arrangement was orderly rather than continuous, and above all that in developing tissue the growing tip of a fibre can be seen advancing on its own, as a separate thing, towards a target it has not yet reached. A net cannot grow a free end. Cajal also drew what he saw rather than photographing it, and his drawings remain in use, which has led to the occasional suggestion that he drew what his theory required; the tissue he worked from has since been re-examined and it does not support the charge.

- E** The two men shared the Nobel Prize in 1906 and used their lectures in Stockholm to contradict each other in front of the same audience, Golgi restating the network he had spent thirty years defending and Cajal restating the case against it. Neither could win, because neither had an instrument that could settle it. What was needed was a way of seeing objects some hundreds of times smaller than the best light microscope could distinguish, and no such instrument existed or was expected.
- F** Meanwhile the functional evidence had already arrived from another direction. Charles Sherrington, studying reflexes, found that transmission through the nervous system is slower than conduction along a fibre, runs in one direction only, and can be fatigued and blocked in ways that continuous conduction cannot. In 1897 he proposed a name for the junction that these properties implied, and called it the synapse, some fifty years before anybody saw one. The name was accepted long before the thing it named was, which is an odd position for a word to occupy.
- G** The electron microscope settled it in the 1950s. Where two neurons meet there is a gap of roughly twenty billionths of a metre, with the membranes of both cells running unbroken on either side of it and machinery on the near side for releasing a chemical across. Cajal had been right, Golgi's method had made the answer possible, and the argument had run for eighty years because the thing everybody was disputing was some hundreds of times smaller than anything either side could resolve.

Questions 14–20

Reading Passage 2 has seven sections, A–G.

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

Write the correct number, I–X.

List of Headings

- i** A reasonable belief, given what could be seen
- ii** An unreasonable belief, held against the evidence
- iii** A method that works by staining almost nothing
- iv** A method that works by staining everything
- v** The inventor draws the wrong conclusion from it
- vi** The inventor is proved right by it
- vii** The same pictures read the other way round
- viii** A prize shared by two men who disagreed
- ix** A name proposed before the thing was seen
- x** An instrument that ended the argument

14 Section A

15 Section B

- 16** Section C
17 Section D
18 Section E
19 Section F
20 Section G

Questions 21–24

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

Match each statement with the correct person, A–C.

NB You may use any letter more than once.

List of People
A Camillo Golgi
B Santiago Ramón y Cajal
C Charles Sherrington

- 21** He found the staining technique on which the whole dispute depended.
22 He argued from the behaviour of reflexes rather than from anything he could see.
23 He pointed to growing fibres with free ends as evidence against a network.
24 He continued to defend his position for three decades after better arguments had appeared.

Questions 25–26

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

- 25** What does the passage say about the charge that Cajal drew what his theory required?
- A** It has never been investigated.
 - B** The original tissue was re-examined and does not support it.
 - C** It was made by Golgi at Stockholm.
 - D** His drawings were replaced by photographs.
- 26** Why, according to the passage, did the argument last as long as it did?
- A** The two men refused to look at each other's evidence.
 - B** The staining method was unreliable.
 - C** The structure in dispute was far smaller than either side could resolve.
 - D** Nobody had proposed a name for the junction.

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

Against efficiency

Nobody argues for waste, and that is the difficulty. Efficiency arrives in any discussion already holding the moral high ground, so that the case against a proposal has to be made in some other language: humanity, or resilience, or quality, none of which has a number attached. The result is a debate in which one side has arithmetic and the other has adjectives, and the arithmetic wins, and about a third of the time it should not have. What is missing is not sentiment. It is a second set of numbers.

The objection is not the romantic one. It is that efficiency is not a property of a system but a relation between a system and a purpose under assumed conditions, and that the assumptions are almost never written down. A process optimised for one set of conditions is by construction less able to deal with any other, because the resources that would have absorbed the difference are exactly what has been removed. Slack is not the opposite of efficiency. It is the price of being wrong about the conditions.

There is a piece of mathematics here that deserves to be better known, because it turns an intuition into a curve. In any system where arrivals are irregular — patients, orders, aircraft, calls — the average delay does not rise smoothly as utilisation increases. It rises gently to about eighty-five per cent of capacity and then goes almost vertical. A hospital running at ninety-five per cent bed occupancy is not slightly busier than one at eighty-five; it is a different animal, one in which a single unexpected admission propagates delays through the whole building for days.

This is not a discovery about hospitals. It is a property of queues, it applies to anything with irregular arrivals and finite capacity, and it means that a manager who drives utilisation towards a hundred per cent is not approaching the ideal. They are approaching a cliff, and the numbers on the way there will look excellent, because average utilisation is high and average delay is still moderate right up until it is not.

The supply chains of the last thirty years are the same story at a larger scale. Holding no inventory is efficient in the precise sense that capital is not tied up in things sitting in a warehouse, and for a long time this was reported as pure gain. The gain was real and it was a payment received in advance for a risk that had not yet been called in. When it was called in, by a fire in a single factory or by a ship in a canal, it became clear that the savings of two decades and the losses of six months were quantities of the same order, which is exactly what an insurance calculation looks like when nobody has done it.

It is important to concede what the efficiency argument gets right, because the concession is large. Slack is genuinely expensive, it is paid for continuously and visibly while the benefit is invisible and occasional, and a great many appeals for it are special pleading by people who would prefer a quieter job. Organisations really do accumulate padding that protects nobody, defended in the language of resilience by people who have never named the event it is held against, and periodically removing it really does make them better. Anybody who has worked in a large institution has seen both the useful slack and the useless kind, and they do not look different from a spreadsheet.

Which is where the practical proposal lies, and it is not a demand for more slack. It is that slack should have to be justified in the same terms as anything else, which means naming the disturbance it is there to absorb, stating roughly how often that disturbance occurs, and pricing it. A reserve that nobody can attach to a named event is padding and should go, and saying so is not an attack on resilience but the only way of defending the part of it that is real. A reserve held against a specific and estimable event is insurance, and cutting it is not an efficiency saving; it is a decision to carry a risk, which is a different thing and should be recorded as one.

The wider point is about which numbers exist. Utilisation is easy to measure and appears on every report. The cost of the disruption that did not happen appears on none, and the person who prevented it has nothing to show. Systems drift towards whatever is being counted, and they will go on drifting towards full utilisation for as long as that is the only quantity in the room, regardless of what anybody in it believes about resilience. Changing the belief changes nothing. Changing the report changes everything.

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 writer thinks all appeals for extra capacity should be granted.
- 28** The writer accepts that removing padding sometimes improves an organisation.
- 29** Hospitals in most countries now run above ninety per cent occupancy.
- 30** The writer believes the case against efficiency is essentially about human values.
- 31** The writer holds that cutting a justified reserve is a decision to accept a risk.
- 32** Firms that held no inventory recovered their losses within six months.

Questions 33–36

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

List of Words

- A slack
- B utilisation
- C insurance
- D padding
- E adjectives
- F conditions
- G cliff
- H inventory

Where the argument goes wrong

Efficiency is a relation between a system and a purpose under assumed **33** which are rarely written down, and the resources that would have absorbed a departure from them are exactly what optimising removes. Driving **34** towards a hundred per cent therefore approaches a **35** rather than an ideal. A reserve held against a named and estimable event is not waste but **36**

Questions 37–40

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

- 37** What does the passage say about average delay as utilisation rises?
- A It rises smoothly in proportion to utilisation.
 - B It stays low until about eighty-five per cent and then rises very steeply.
 - C It falls once utilisation passes ninety per cent.
 - D It depends only on the number of arrivals.
- 38** Which position does the writer reject?
- A That slack is expensive and paid for continuously.
 - B That efficiency should be argued for in the language of humanity and quality.
 - C That organisations accumulate padding that protects nobody.
 - D That a reserve should be attached to a named event.

- 39** How does the passage describe the savings from holding no inventory?
- A** As a loss disguised as a gain.
 - B** As a payment received in advance for a risk not yet called in.
 - C** As an error that was obvious at the time.
 - D** As smaller than they appeared on paper.
- 40** Which of the following best expresses the writer's conclusion?
- A** Systems drift towards whatever is being counted, so the report must change.
 - B** Efficiency should be abandoned as a goal.
 - C** Managers should be trained to value resilience.
 - D** Inventory should always be held in large quantities.