Please check the examination details below before entering your candidate information

Candidate surname	Other names

Pearson Edexcel
International
Advanced Level

Centre Number | | | | | |

Candidate Number | | | | |

Thursday 1 November 2018

Morning (Time: 1 hour 45 minutes) | Paper Reference **WBI05/01**

Biology
Advanced
Unit 5: Energy, Exercise and Coordination

You must have:
A copy of the scientific article (enclosed), calculator, HB pencil, ruler.

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

Information

- The total mark for this paper is 90.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- Questions labelled with an **asterisk** (*) are ones where the quality of your written communication will be assessed
  – *you should take particular care with your spelling, punctuation and grammar, as well as the clarity of expression, on these questions.*
- Candidates may use a calculator.

Advice

- Read each question carefully before you start to answer it.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

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Answer ALL questions.

Some questions must be answered with a cross in a box ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 Neurones conduct impulses. Some neurones are surrounded by myelin, a fatty substance.

(a) Put a cross ☒ in the box next to the name of the cell that produces the myelin sheath.

(1)

☒ **A** motor neurone

☒ **B** relay neurone

☒ **C** rod cell

☒ **D** Schwann cell

(b) Put a cross ☒ in the box next to the phrase that completes each of the following statements.

(i) Myelin is

(1)

☒ **A** an electrical conductor

☒ **B** an electrical insulator

☒ **C** permeable to potassium ions

☒ **D** permeable to sodium ions

(ii) Myelin surrounds the

(1)

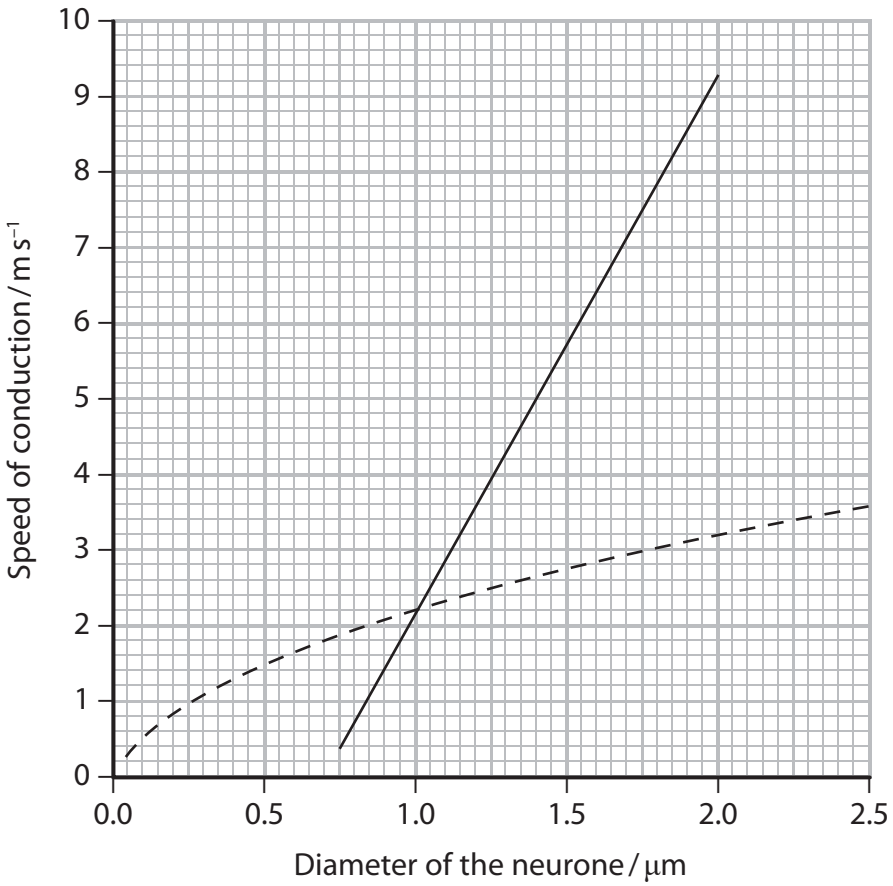
☒ **A** axon

☒ **B** cell body

☒ **C** post-synaptic membrane

☒ **D** synaptic knob

(c) The graph below shows the effect of myelination and the diameter of the neurone on the speed of conduction of nerve impulses.



(i) Calculate the percentage increase in the speed of conduction due to the myelination of a neurone with a diameter of 1.5 μm.

(3)

Show your working.

.....%

(ii) Using the information in the graph, compare the speed of conduction in myelinated and non-myelinated neurones.

(2)

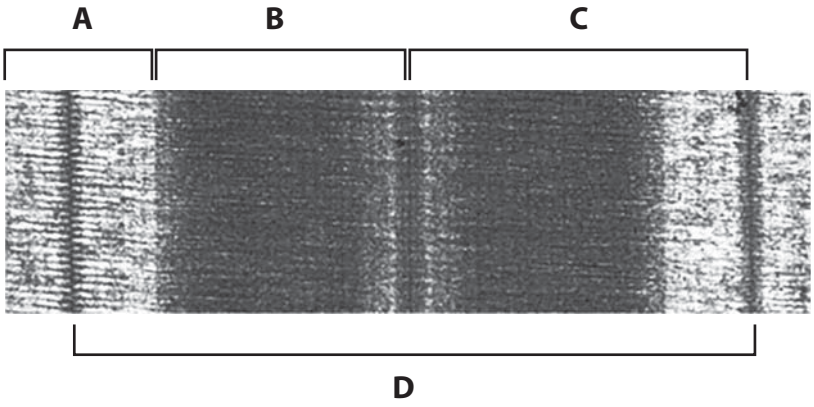
(iii) Explain why the speed of conduction in a myelinated neurone with a diameter of 1.5 μm is faster than in a non-myelinated neurone with the same diameter.

(3)

(Total for Question 1 = 11 marks)

2 Skeletal muscles contain fast twitch and slow twitch muscle fibres. These are important in the movement of the body.

The electron micrograph below shows part of a muscle fibre.



Magnification ×50 000

(a) Calculate the actual length of the part labelled D.

Give your answer in millimetres in standard form.

(2)

..... mm

(b) Put a cross ☒ in the box that completes each statement about this muscle fibre.

(i) The sarcomere is the part labelled

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(ii) The region containing actin but not myosin is the part labelled

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(iii) When this muscle fibre contracts, the length of

(1)

	part A	part B
☒ **A**	decreases	decreases
☒ **B**	decreases	stays the same
☒ **C**	stays the same	decreases
☒ **D**	stays the same	stays the same

(c) Put a cross ☒ in the box that completes the statement about muscle fibres.

Fast twitch muscle fibres have

(1)

☒ **A** few mitochondria and few capillaries

☒ **B** few mitochondria and many capillaries

☒ **C** many mitochondria and few capillaries

☒ **D** many mitochondria and many capillaries

(d) Describe the role of calcium ions, in muscle cells, in muscle contraction.

(3)

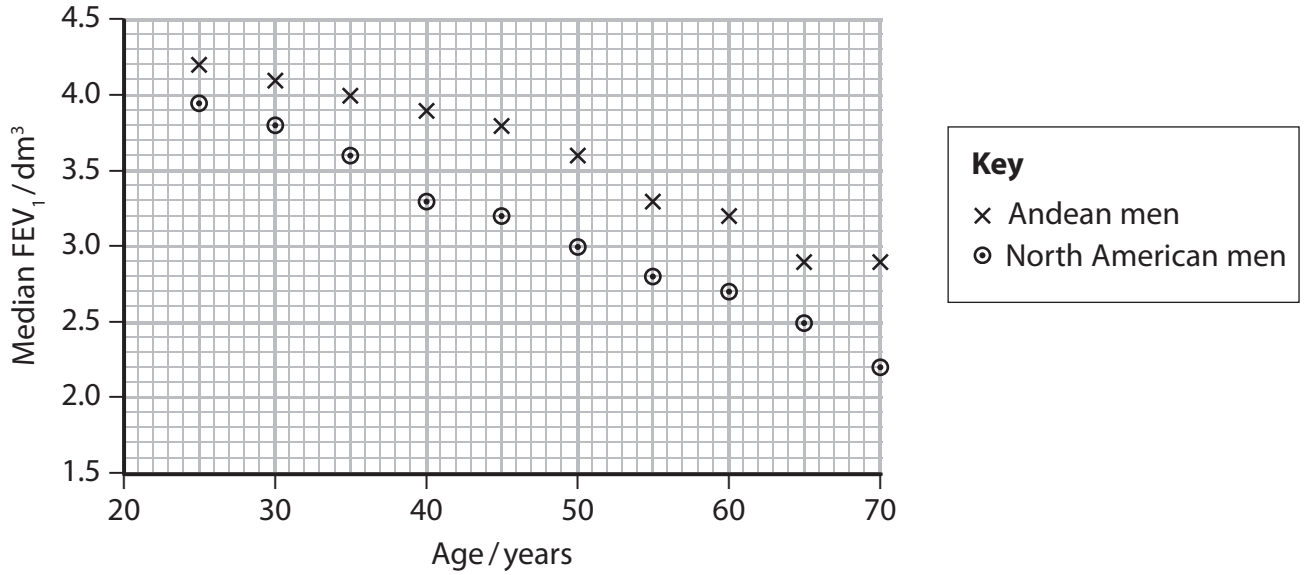
(Total for Question 2 = 9 marks)

3 A spirometer can be used to record the ventilation of the lungs.

Andean men live on mountains in South America. The breathing of Andean men living at high altitude and that of North American men living at low altitude has been investigated.

(a) The maximum volume of air that can be breathed out in one second is known as the FEV_1.

The graph below shows the median FEV_1 for Andean and North American men of different ages.



(i) Using the information in the graph, describe the effects of age and altitude on the median FEV_1.

(2)

(ii) Suggest **two** reasons for the effect of age on the median FEV_1 for North American men.

(2)

(iii) Explain the differences in the median FEV_1 for Andean men and North American men.

(2)

(b) A spirometer can be used to measure the breathing rate.

Describe how the data obtained from a spirometer could be used to compare the median breathing rates of Andean men and North American men.

(3)

(Total for Question 3 = 9 marks)

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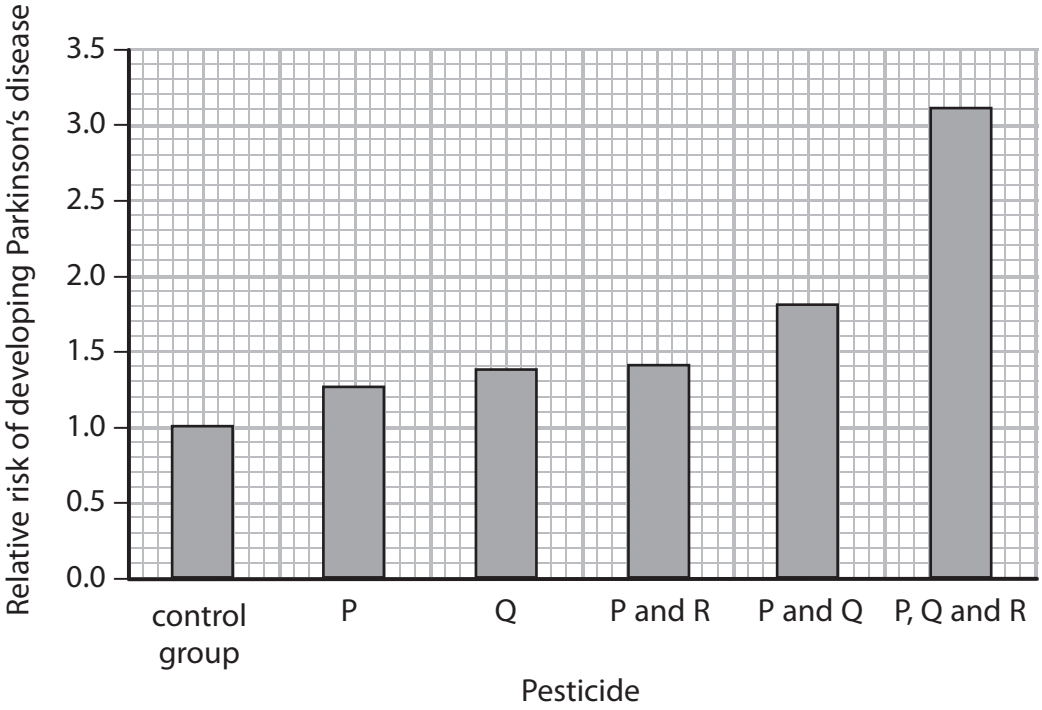
4 Parkinson's disease can develop after exposure to certain environmental factors.

The relative risk of developing Parkinson's disease in people exposed to different pesticides has been studied.

(a) Data were collected for people exposed to different combinations of three pesticides, P, Q and R.

People exposed to pesticides were compared with a control group. People in the control group were not exposed to pesticides.

The results are shown in the graph below.



Using the information in the graph, describe the effect of exposure to pesticides on the relative risk of developing Parkinson's disease.

(2)

(b) One symptom of Parkinson's disease is the loss of muscle control.

(i) Suggest how exposure to pesticides might cause a loss of muscle control.

(3)

(ii) Explain how people with Parkinson's disease can be treated.

(3)

(Total for Question 4 = 8 marks)

5 Black bears survive cold winters by hibernating in dens.

During hibernation, black bears maintain their core body temperature within narrow limits.

(a) Put a cross ☒ in the box next to the word that completes the following statement.

(1)

The process of maintaining a steady core body temperature is an example of

☒ **A** chemiosmosis

☒ **B** homeostasis

☒ **C** phototropism

☒ **D** respiration

(b) The photograph below shows a bear hibernating in its den.

The temperature in the den was –10 °C.

Magnification ×0.05

In one investigation, the metabolic activity, core body temperature and shivering of a hibernating bear were measured.

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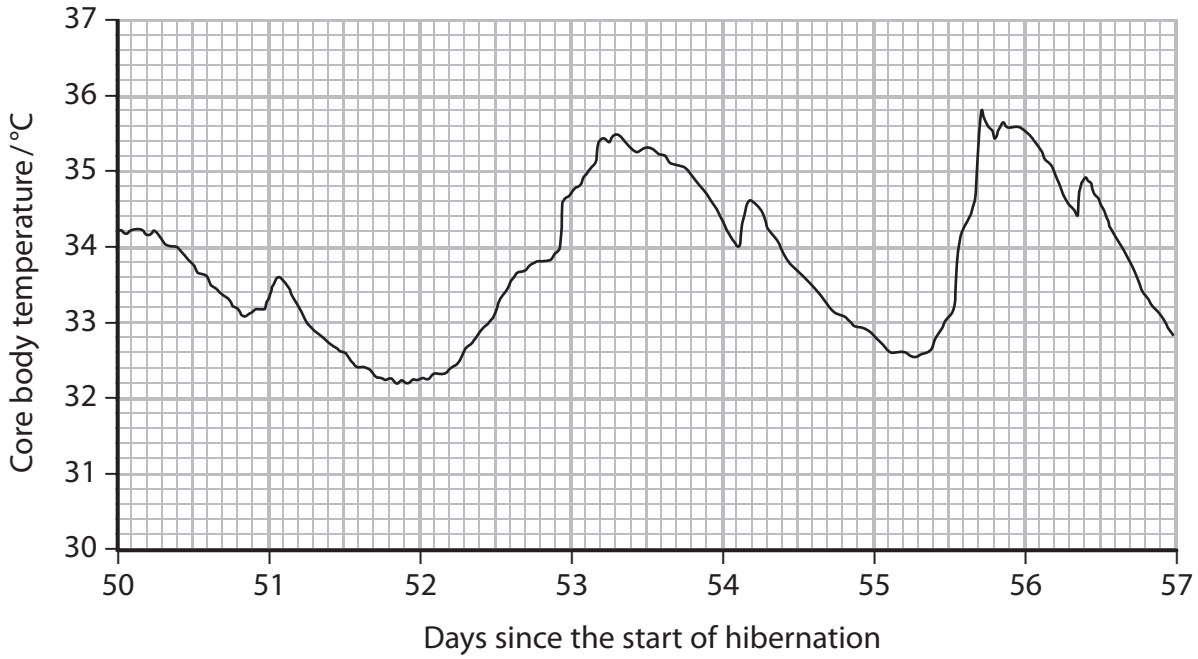
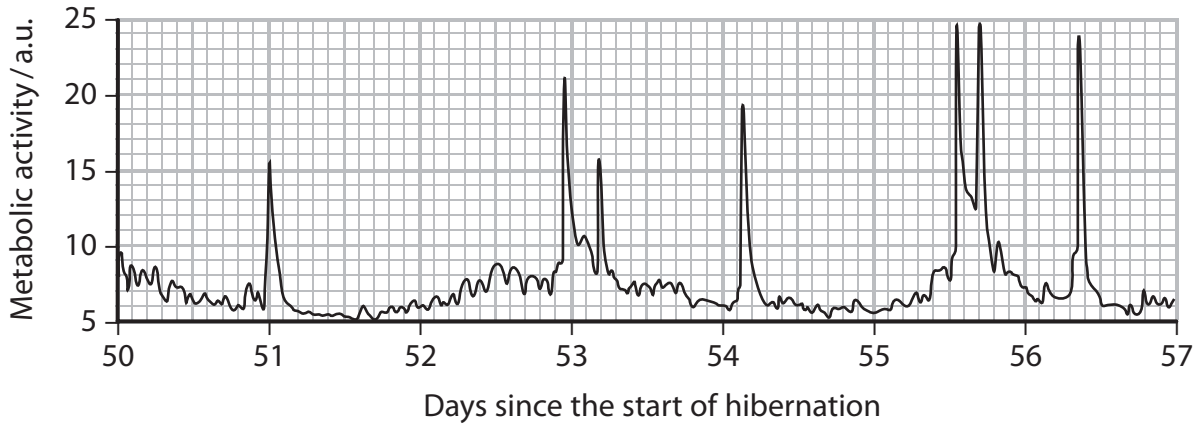
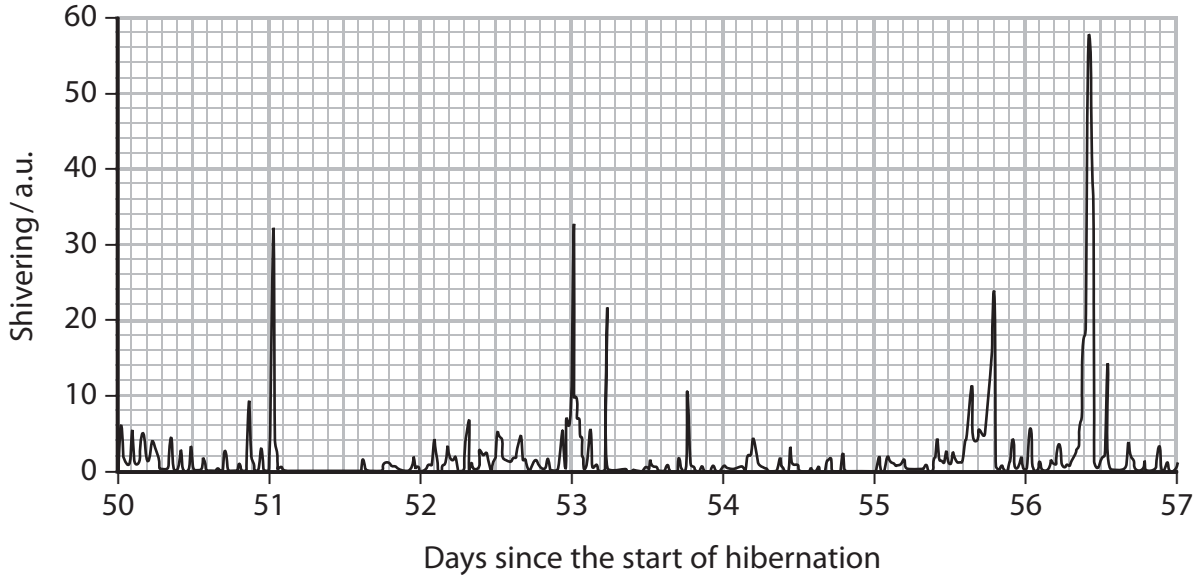
The graphs below show the results of this investigation.







*(i) Using the information in the photograph and the graphs, explain how the bear maintains its core body temperature during hibernation.

(5)

(ii) Explain what will happen to the body mass of the bear during hibernation.

(2)

(c) Black bears living near the paths used by humans can become habituated to the presence of humans.

(i) Put a cross ☒ in the box next to the row in the table that could increase the chance of these bears becoming habituated.

(1)

	Food source in areas around the paths	Number of bears living near paths
☒ **A**	decreases	decreases
☒ **B**	decreases	increases
☒ **C**	increases	decreases
☒ **D**	increases	increases

(ii) Describe how habituation of black bears to the presence of humans could be investigated.

(4)

(Total for Question 5 = 13 marks)

6 Erythropoietin (EPO) is a hormone that stimulates the production of red blood cells in bone marrow.

The gene for this protein hormone is active in kidney cells.

(a) The effect on EPO synthesis when kidney cells are exposed to different oxygen concentrations for different periods of time was investigated.

The table below shows the results of this investigation.

Oxygen concentration (%)	EPO synthesis / a.u.				
	1 hour	3 hours	6 hours	12 hours	24 hours
20	0.2	0.4	0.4	0.7	1.2
3	0.2	0.4	0.6	1.8	7.3
1	0.5	0.5	1.0	4.2	20.2

(i) Using the information in the table, describe the results of this investigation.

(2)

.....

.....

.....

.....

.....

.....

(ii) Suggest how changes in oxygen concentration can result in a change in the synthesis of the protein EPO by these kidney cells.

(4)

(b) People with kidney failure are unable to synthesise EPO.

These people can be treated with EPO made by genetically modified sheep.

Describe how a sheep could be genetically modified to produce EPO in its milk.

(4)

(Total for Question 6 = 10 marks)

7 The scientific article you have studied is adapted from:

'Heart, the inside story of our body's most important organ'.

Use the information from this article and your own knowledge to answer the following questions.

(a) Suggest why 'super-fit young footballers' are more likely to develop viral infections (paragraph 5).

(2)

(b) Explain why 'regular boosters as an adult' will reduce the risk of developing myocarditis' (paragraph 6).

(3)

(c) Suggest how 'happiness hormones (endorphins)' cause the euphoric feeling experienced by some long-distance runners (paragraph 8).

(3)

(d) Explain why an unfit heart has to beat much more quickly than a trained one (paragraph 10).

(2)

(e) Describe the role of the sinoatrial node in regulating the pulse rate of rats (paragraph 13).

(3)

(f) Describe how membrane channels allow pacemaker cells to depolarise (paragraph 13).

(3)

(g) The article suggests that exposure to exercise resulted in a change in the number of genes in rats, 'sports rats had far fewer genes for these ion channels' (paragraph 13).

Discuss this statement.

(3)

*(h) The beta-1-adrenergic receptor is a glycoprotein present in cell membranes (paragraph 17).

Describe how the rough endoplasmic reticulum (rER) and the Golgi apparatus ensure that this glycoprotein is present in the cell membrane.

(5)

(i) Suggest how the electrocardiogram (ECG) of a heart would change in someone treated with beta blockers (paragraph 18).

(1)

(j) Suggest how the adrenalin in nose sprays reduces swelling (paragraph 21).

(2)

(k) Explain how atropine causes dilation of the pupils of the eye (paragraph 22).

(3)

(Total for Question 7 = 30 marks)

TOTAL FOR PAPER = 90 MARKS

Pearson Edexcel
International Advanced Level

Biology
Advanced
Unit 5: Energy, Exercise and Coordination

November 2018

Scientific Article for use with Question 7

Paper Reference

WBI05/01

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Scientific article for use with Question 7

Adapted from: Heart, the inside story of our body's most important organ. Johannes Hinrich von Borstel (Translated by David Shaw), Scribe publications 2016.

A Red Card for the Heart

1. Beep, beep, beep, beep, beep. It's 6.30 in the morning and your alarm clock is going off. You sit up in bed, but bwah! You feel like death warmed up. It looks like you've caught a cold. Yesterday you had a slight tickling in your nose and now you feel like a boxer's punching bag at the end of a long training session. And you haven't even tried getting out of bed yet. You struggle to your feet; your every move is painful. Maybe a painkiller will help? So you swallow a tablet and take a shower. Then off you go to work. It seems like the pill has done its job and you feel a little better. A good thing, too, because you have a desk full of work to get through at the office.

2. Which of us hasn't been there? Who has not taken an illness into work with them? With the noble aim of not disappointing the boss and leaving our workmates in the lurch. But is it healthy? Of course it isn't. And you're doing harm not only to yourself, but also to your co-workers, who you might find sniffling just like you at the office tomorrow.

3. It can't be as bad as all that, you think. Whether you let such a trivial cold keep you in bed or you pop a painkiller and drag yourself into work doesn't make all that much difference in the grand scheme of things, surely? You could hardly be more wrong! With your overactive sense of duty, you might just be setting the foundations for an inflammation of the heart muscle, or myocarditis. And it is anything but trivial. The pathogens that cause myocarditis do not attack the muscles of the heart alone, but the coronary arteries, too. This can weaken the entire organ to such an extent that it causes permanent heart failure, with all the unpleasant side effects this entails.

4. A serious case of myocarditis can even be fatal. It is extremely difficult to recognise and so hard figures about the frequency of deaths caused by myocarditis are lacking. Figures from Germany's Federal Statistical Office show that 3797 inpatients were diagnosed with acute myocarditis in 2012. The number of undiagnosed cases is likely to be far higher.

5. Myocarditis is so dangerous because it can strike anyone, irrespective of age. This is why we see cases again and again of apparently super-fit young footballers suddenly collapsing on the pitch in the middle of a game. Diagnosis: sudden cardiac death. It can be caused by a lingering flu infection, which is actually a harmless viral infection, but failure to rest sufficiently and recover fully can allow the virus to spread through the body and attack the heart. When this happens, any sporting activity places an extra burden on the heart, which may turn out to be the last straw.

6. If a patient gets enough rest, and recovers fully from the infection, myocarditis is very unlikely. In fact, there's an effective preventive measure. One good way to reduce the risk of developing myocarditis is to follow all your primary vaccinations as a child with regular boosters as an adult. Those who also eat a healthy diet get enough sleep and do regular physical exercise, will both improve the performance level of their entire body, and protect it from all kinds of illnesses. Not least of all myocarditis.

Jump, Heart, Jump

7. Despite the regular appearance of headlines about professional athletes suffering sudden cardiac death, you would be hard pressed to find a medical professional who doesn't believe that physical exercise is good for the heart. Indeed, there is a unanimous opinion that physical fitness plays an

important part in cardiac health. A large number of scientific studies agree that regular exercise lowers the risk of dying early from cardiac or vascular disease. It also makes us better able to cope with stress, and that is also good for the heart. But what kind of sport is best for us? After all, we want to do our bodies a favour, not do lasting damage to our joints or other parts of our body.

8. For many, the ideal sport is running. Recently, a friend told me about the 'runner's high'. This is a kind of euphoric feeling often experienced by endurance athletes, especially long-distance runners. It's caused by happiness hormones (endorphins), which can suddenly make an athlete feel light and able to carry on running forever without ever getting tired. As someone who isn't particularly sporty, I decided I wanted to experience that, if only just once. There was only one thing for it: to try out an experiment on myself!

3.00 p.m.: Fired up with enthusiasm, I head up to the loft in search of my old jogging shorts and running shoes. After clearing a load of junk out of the way, I find them in an old cardboard box. These shoes look almost new, I think to myself, as I blow a layer of dust off them.

4.05 p.m.: I find a spider in one of the shoes. With my toes. While putting them on. I finally get over my disgust and solve the problem using the vacuum cleaner. Such trifling obstacles are not enough to stop me.

4.11 p.m.: I'm standing outside the house in my running gear, mentally preparing for the upcoming event. One of my neighbours appears and stops for a 'quick chat'.

4.55 p.m.: All necessary neighbourly information having been exchanged, my quest for the legendary runner's high can now begin. With admittedly mixed feelings, I set off towards the local woods.

4.57 p.m.: I begin to feel the first sensations of effort in my body. A tightening in my leg muscles especially. This is perfectly normal, I suppose. After all, I haven't been out running for quite a while. I will certainly not let it stop me.

5.01 p.m.: I'm now feeling muscles I didn't even know I had. It's not a pleasant feeling. But I'll wait and see — maybe the feeling will go away again.

5.04 p.m.: I feel the worst case of aching muscles in the history of the world coming on.

5.07 p.m.: I'm starting to come to terms with the idea that I will be bedridden for the next few weeks, at least, perhaps even for the rest of my life.

5.10 p.m.: The pain is now almost more than I can bear. I consider whether it might be less painful to stumble into a pothole deliberately and just destroy all my body's joints and muscles in one fell swoop.

5.11 p.m.: I am now on the lookout for suitable potholes, but instead I spot a bench. Break time! As I flop down on the bench, I suddenly remember my friend advising me to do a couple of push-ups during running breaks, to keep my momentum going.

5.12 p.m.: I lay face-down in the dirt of the forest floor, panting. Suddenly hearing voices, I push myself up with a groan, and start to count loudly enough for people to hear: ….. 313, 314, 315 …… !' Seconds later, when the ramblers are out of earshot, I slump to the ground like a sack of potatoes.

5.15 p.m.: I am on my way home. Walking. No, limping.

9. If only someone had told me earlier that not everyone experiences a runners high — and those who do are mostly highly trained athletes. And still it's only likely to occur when a practised runner pushes his or her body to the limits of endurance.

10. If you think of the heart as an engine, it becomes clear why (sudden cardiac deaths notwithstanding) athletes have a higher life expectancy than the less athletically inclined. An engine that's permanently running at the highest number of revs per minute will break down more quickly than one that constantly runs at a pleasant low speed. And the same is true of an unfit heart, which has to beat much more quickly to supply the body with blood than a trained one.

11. A sample calculation might be the best way to explain this. Let's say an untrained heart has to beat 80 times a minute on average, while a well-trained heart only has to beat 50 times in the period. After 70 years, the unfit heart will have beaten almost 3 billion times, compared to 1.8 billion beats for the fit organ. That's about 40 per cent fewer beats. Well, that sounds great. But is it as good as it sounds?

12. Don't people say sport is bad for you? After all, we often hear about the problems of sports professionals — especially at the end of their careers when they're not training as intensively as they used to — suffering from enlarged-heart syndrome and dying early. But this is only true, if at all, for top athletes. Experts are in no doubt that, for amateurs, sport is definitely not bad for you. On the contrary, it plays a major role in maintaining a strong and healthy heart. And should any of you still be worried about 'athletic-heart syndrome', the best advice is not to abruptly abandon sporting exercise after years of training, but to 'train down'; that is, slowly but surely reduce your training schedule. Then nothing untoward can happen.

13. A group of researchers in Manchester investigated the effect of sport on the pacemaker cells of the heart in rats. They had one group of rodents ('sports rats', if you like) spend an hour running on a treadmill every day for 12 weeks, while a second group (we might call them 'cage-potato rats') were allowed to avoid any kind of physical exertion. At the end of the experiment, the physically active sports rats had a significantly lower resting pulse rate than their lazy colleagues. The researchers found out that this was due to changes to the rats' sinoatrial node, the primary pacemaker of the heart, where ion currents through certain membrane channels enable the pacemaker cells to stimulate themselves. When the scientists investigated the genetic code of these cells, they found that the sports rats had far fewer genes for these ion channels, known rather amusingly as 'funny channels', than those of the lazy animals. From this, they concluded that regular exercise had caused a permanent change in the internal structure of the heart's primary pacemaker.

The Fight-or-flight Rocket-propulsion System

14. What turned me into such a fast sprinter on the way home from school wasn't just my legs, but also a part of my nervous system. The autonomic part, to be precise, which can be thought of as 'the nervous system of the organs'. Although the sinoatrial node is the primary pacemaker in the heart, higher-ranking centres can considerably influence its activity via the autonomic nervous system.

15. The autonomic nervous system has two branches, with contrary effects: the sympathetic and the parasympathetic nervous systems. Together, they control most of our bodily functions. Including, importantly, those of the heart. And although they're complete opposites, they complement each other perfectly. When we find ourselves in an emergency situation, our sympathetic nervous system immediately puts us on the alert. It dilates our pupils to improve our vision in bad light, it increases the activity of our muscles so that we're ready for a fight or so that we can run away more quickly, and it dilates our bronchial tubes so that we can breathe more efficiently. The American

psychologist Walter Cannon coined the term 'fight or flight response' to describe this entire complex of reactions. What a perfect description! When I was running away from the big boys after school I was in flight (that is, fleeing), and my sympathetic nervous system was my inexhaustible rocket-propulsion system.

16. The parasympathetic nervous system has the opposite, 'relaxing' effect, which is activated, for instance, after a large meal, when we fall into what some people call a food coma. It's that feeling of postprandial somnolence, to use the more scientific term, that causes us to flop onto the sofa in a stupor after a big meal. This happens when digestion has top priority for the nervous system. The parasympathetic nervous system winds down our body's overall level of activity and increases the supply of blood to the stomach, gut, and liver. This phenomenon has been dubbed 'rest and digest', along the lines of Cannons famous coinage.

17. The sympathetic nervous system has several different effects on the heart. One is to accelerate the heart rate, and this can be directly ascribed to the influence of the sinoatrial node. It can also increase the force of the heart's contraction. The mechanism controlling this is the activation of something called beta-1 adrenergic receptors in the cell membranes. It also reduces the duration of contractions, so that the heart can beat more quickly — and I could run away from the big boys faster.

18. Luckily, the highly complex autonomic nervous system can be influenced with medical drugs, which is extremely useful in the treatment of chronic cardiovascular disease, and especially in emergency medicine. One well-known set of drugs of this type is the beta blockers, which, as the name implies, block the beta receptors mentioned above, thus lowering blood pressure and reducing the pulse rate. Another set of drugs that influence the autonomic nervous system are those extracted from plants of the digitalis family, notably the foxglove. These are used to treat patients with severe cardiac insufficiency because they increase cardiac contractility (the strength of the heart's contractions) while simultaneously reducing heart rate.

19. The dramatic case of a cardiac arrest calls for even more drastic intervention: medics increase the activity of the patients sympathetic nervous system and simultaneously decrease that of the parasympathetic system by administering adrenaline and atropine. Adrenaline is known as a sympathomimetic drug; this term is a fitting one, given its function, since it comes from the Greek word mimesis, meaning 'imitate'. Adrenaline imitates the sympathetic nervous system, meaning it increases its activity, thus raising the patients heart rate, expanding the bronchial tubes and increasing blood pressure.

20. Atropine, by contrast, acts as a parasympathetic, which means something like 'blocker of parasympathetic effects'. Thus, it reduces the influence of the parasympathetic nerves on the heart. After these two drugs with similar effects have been administered, resuscitation efforts to restart the heart are much more likely to succeed.

21. The effects of all these drugs are by no means restricted to the cardiovascular system. In small doses, they can be useful in normal, everyday life. For example, some nose sprays contain adrenaline (a.k.a. epinephrine), which causes the blood vessels in the mucous membrane inside the nose to contract, rapidly reducing swelling. However, this effect only keeps working if the spray isn't used too often — otherwise, a so-called rebound effect kicks in, increasing the blood supply to the mucous membranes and allowing them to swell up again. No wonder so many people become almost addicted to such nose sprays.

22. Furthermore, atropine analogues* are used by ophthalmologists. When administered as eye drops, these inhibit the effects of the parasympathetic system on the eyes, which include the contraction of the pupils. As a result, the influence of the sympathetic system gains the upper hand and the patients pupils dilate. This makes it easier for the ophthalmologist to examine the interior of the eye, especially the retina. An unpleasant, but completely harmless side effect for the patient is extremely blurred vision for a couple of hours.

23. Dilated pupils, especially women's, used to be considered an attractive feature, so many ladies in the past would use atropine-based eye drops. Atropine was extracted from a poisonous plant, the deadly nightshade, which explains this plant's scientific name, belladonna — 'beautiful lady' in Italian.

Seeing Red

24. Because it has so many important functions, blood is quite often and quite reasonably called a liquid organ. On average, human adults have between five and six litres of it flowing through their veins and arteries. Blood is made up of both liquid and solid components. The liquid part, the plasma, makes up about 55 per cent of the blood in an adult male† and consists mainly of water, proteins, salts, and monosaccharides, but also a wide variety of many other substances. Another 44 per cent is made up of solid components, called haematocrit, which consists mainly of our various blood corpuscles and the specialist cells of the immune system.

25. A while ago, when I was playing with my little niece in her treehouse, she said something that really got me thinking. Clumsy as always, I had hurt my arm, and after she'd blown extensively on the graze to 'make it better', she said in surprise, 'Your blood looks a bit like tomato sauce.' How right she was becomes clear when you consider not only the appearance of blood, but also its properties. It is red and viscous and, like sauce, contains sugar and other solid components. From a physicists point of view, blood is a non-Newtonian fluid, which actually means nothing more than that it has different flowing properties than water. This is due to the fact that blood contains a lot of substances that, unlike salt in water, aren't dissolved in the plasma.

26. This kind of a mixture of a liquid and undissolved solids is called a suspension. In blood, this is seen in the fact that its properties change with its flow speed. The faster blood flows, the more emulsified the suspension becomes, which means the finer the mix of fluids (which are actually immiscible) becomes. This is due to the plasticity of our red blood cells. If you drop a spoonful of olive oil into a glass of water, the two liquids don't initially mix, and the oil forms a thick film floating on top of the water. If you stir it vigorously, the oil will be distributed throughout the water in the form of tiny droplets. What you then have is an emulsion. In the case of blood, when it's flowing fast, the corpuscles act almost like those droplets of olive oil in water.

27. The corpuscles in our blood include the previously mentioned red and white blood cells, as well as cells known as platelets, which play a role in blood coagulation when we injure ourselves. If you are clumsy enough to graze your arm, they immediately begin a process to staunch the bleeding from the wound. They do this by quickly clumping together in great numbers and releasing a threadlike protein called fibrin. A fibrin strand is 1000 times finer than a human hair and is one of the most elastic substances known to biology. The fibrin strands form a dense net, which stops the wound from bleeding. Under certain circumstances, this mechanism can save lives.

* In chemistry and pharmacology, analogues are chemicals that have similar functions or structures.
† This figure is slightly higher in women.

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