



## **GCE Biology**

S21-A400U30-1

### **Assessment Resource 21**

Requirements for Life- Options Resource C

**SECTION B: OPTIONAL TOPICS**

Option A: **Immunology and Disease**

Option B: **Human Musculoskeletal Anatomy**

Option C: **Neurobiology and Behaviour**

Answer the question on **one topic only**.

Place a tick (✓) in **one** of the boxes above, to show which topic you are answering.

**You are advised to spend about 30 minutes on this section.**

**Option A: Immunology and Disease**

1. Zika is an RNA virus, which can be spread by the *Aedes* mosquito. Most people infected with the Zika virus experience no or very mild symptoms. A recent outbreak in South America was accompanied by an increase in the number of babies being born with microcephaly (a significantly smaller head and abnormal brain development). The incubation period for the Zika virus is estimated to range between 3 and 12 days. The symptoms, if experienced, are similar to other mosquito-borne diseases such as malaria and include: fever, rash, muscular pain, joint pain and headaches.

In 2016, concern was expressed by athletes travelling to the Olympics in Brazil regarding possible infection with Zika. The World Health Organisation concluded that the risk of transmission was relatively low. The advice given to anyone travelling to the Olympics was:

- use insect repellent and wear loose clothing that covers the body
- keep windows closed at night and sleep under a mosquito net
- avoid areas with poor sanitation and stagnant water.

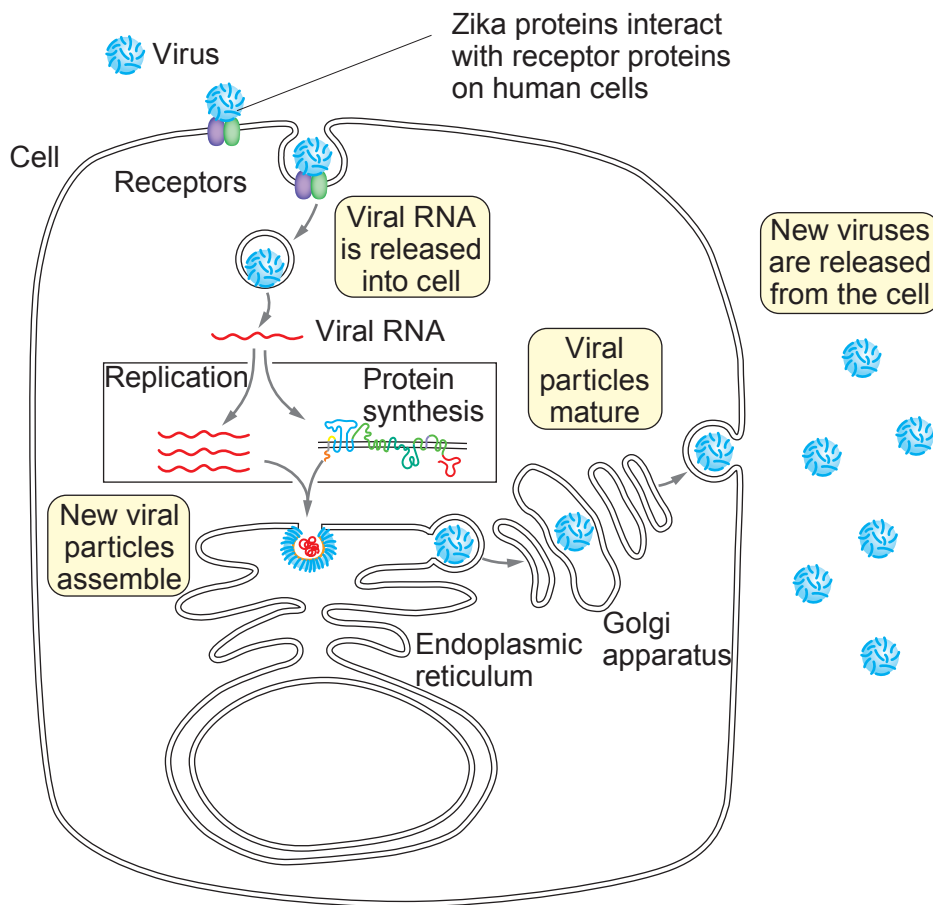
(a) (i) State the term given to the *Aedes* mosquito in the lifecycle of the Zika virus. [1]

.....

(ii) Explain how the preventative methods described above would help reduce the chance of infection with Zika. [2]

.....  
.....  
.....  
.....  
.....

(b) The diagram below describes how the Zika virus replicates inside a human cell.



(i) With reference to the diagram, suggest why viruses are difficult to treat with drugs and state the challenges faced when attempting to develop a vaccine against Zika. [3]

.....

.....

.....

.....

.....

.....

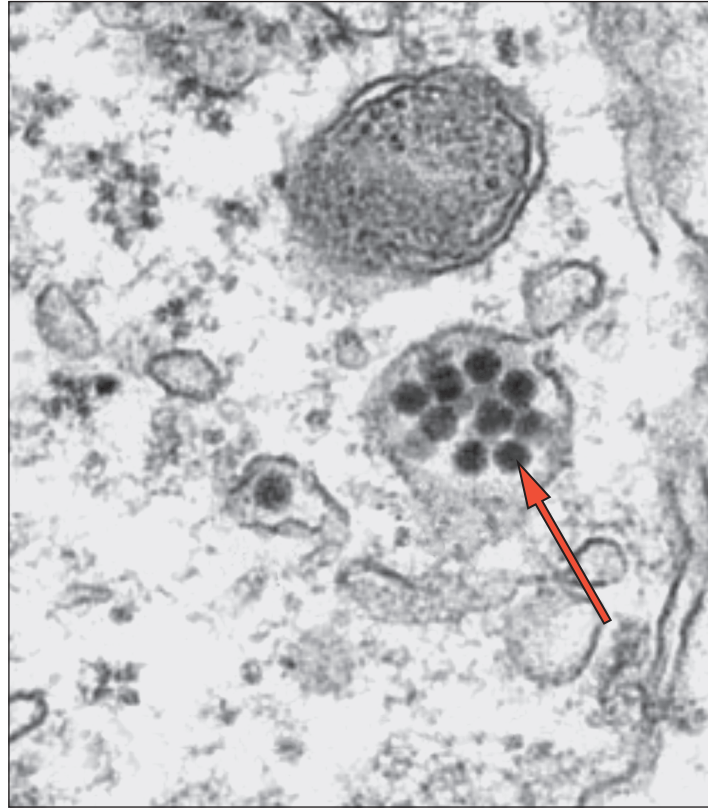
(ii) State **two** features of a successful vaccine. [1]

.....

.....



- (d) The image below is an electron micrograph showing part of a human cell infected with Zika. Virus particles are in membranous vesicles, the **arrow on the micrograph** below indicates **one virus particle**.



500 nm

Use the scale bar to calculate the diameter of the labelled Zika virus particle. [2]

Diameter = ..... nm

(e) Methicillin works in a similar way to penicillin and is said to be bactericidal. It is no longer produced for medical use because of the rapid increase in bacterial resistance to it. Methicillin resistant *Staphylococcus aureus* (MRSA) is endemic in the general human population. Infections caused by MRSA are common in hospital patients.

(i) State what is meant by the term *endemic* and suggest why MRSA is not a major cause for concern amongst the general population. [2]

.....

.....

.....

(ii) Erythromycin can be bactericidal or bacteriostatic depending on the dose. It binds to the large ribosomal subunit in bacterial cells. Suggest how erythromycin may work to treat bacterial infection and why it does not affect the patient's cell metabolism. [2]

.....

.....

.....

(f) Antibiotic resistance is a global crisis and measures are needed to control the use of antibiotics as well as developing new antibiotics. Clinical trials need to be done on any new antibiotic. A trial was carried out to test the safety of a new antibiotic using 20 healthy male volunteers from the same ethnic background. Evaluate the validity of this trial in terms of its use in the whole population. [2]

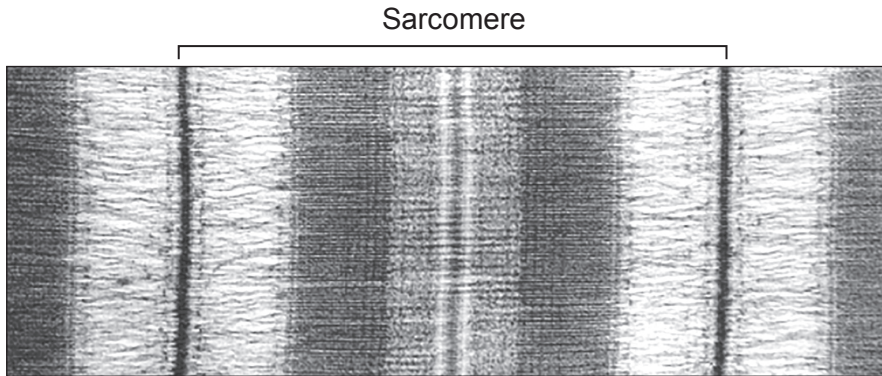
.....

.....

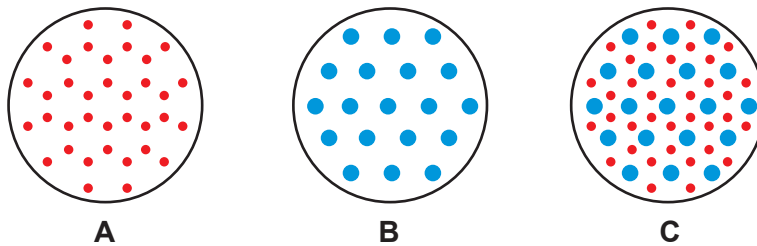
.....

**Option B: Human Musculoskeletal Anatomy**

2. Skeletal muscle is made up of bundles of fibres, which have a striated appearance. Each fibre contains numerous myofibrils. The image below shows a micrograph of a sarcomere.



The drawings below represent the same structure from different regions but in a different plane from the image above.



- (a) (i) State whether circles **A-C** represent transverse or longitudinal sections. [1]

.....

- (ii) With reference to the micrograph, for each of the circles state which region of the sarcomere they are taken from and explain your reasoning. [3]

**A** .....

.....

**B** .....

.....

**C** .....

.....



(iii) Describe how the different protein fibres interact to bring about contraction of the sarcomere. [4]

.....

.....

.....

.....

.....

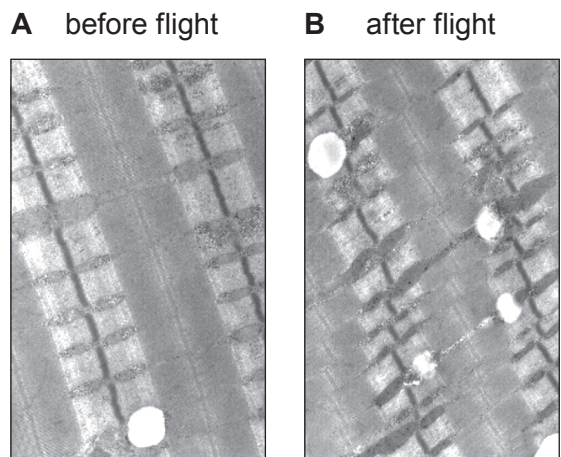
.....

.....

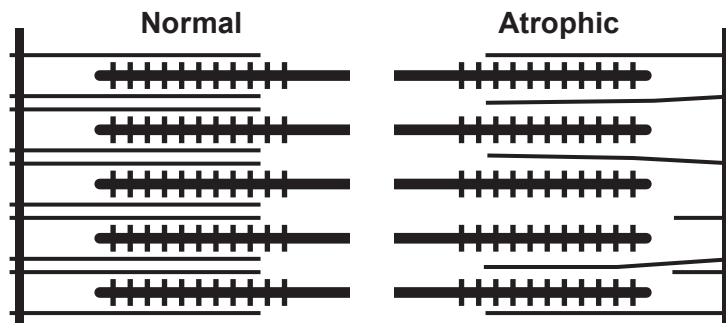
.....

(b) In 2016 Tim Peake was the first British astronaut to spend time on the International Space Station. Research has taken place on astronauts into the effect of prolonged space flight on muscle atrophy. During space flight, astronauts have to exercise, often spending several hours per day on a treadmill.

The images below show electron micrographs of muscle fibres obtained from the muscles of an astronaut before (A) and after (B) a 17-day space flight. The before flight fibres have wider myofibrils whereas myofibrils after flight are narrower, indicating atrophy.



The diagram below represents the atrophy demonstrated in the protein fibres after flight when compared to normal protein fibres.



(i) Why is it important that muscle sample, before and after flight, is taken from the same muscle in the same astronaut? [1]

.....

(ii) Using the image and your knowledge of muscle contraction, conclude how spaceflight would affect the maximum force that the muscle could generate. [2]

.....

.....

.....

.....

(c) The bones of the skeleton can fracture for a variety of reasons. The X-rays below show two such injuries:

**C** Lower right leg



**D** Left hip



X-ray **C** is taken from a healthy 19-year-old male with a displaced fracture of the fibula. X-ray **D** is from a 75-year-old woman, suffering from osteoporosis with a non-displaced fracture of the femur.

(i) Explain why the fracture shown in X-ray **C** is more likely to heal with the best chance of full recovery than the fracture shown in X-ray **D**. [2]

.....

.....

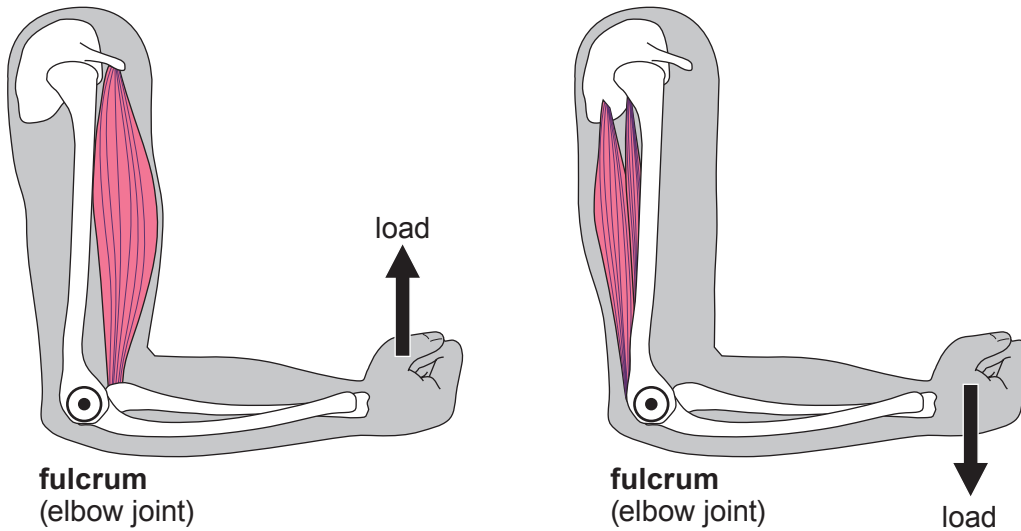
.....

(ii) Both fractures required surgery and the use of screws and/or metal plates. Suggest why this treatment would lead to a faster recovery than bed rest or immobilisation. [1]

.....

.....

(d) The drawings below show the muscles that control movement of the lower arm. These muscles work with the elbow joint as levers.



(i) State the orders of lever represented in the elbow joint when the: [1]

Biceps are contracting .....

Triceps are contracting .....

(ii) Explain why there is a difference in the type of lever represented when the arm is being bent and straightened. [2]

.....

.....

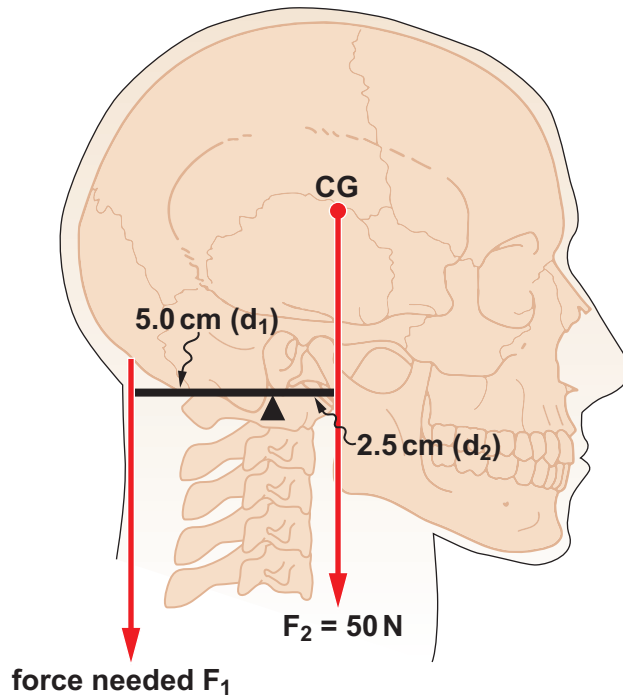
.....

.....

(iii) In experiments to determine the force generated by the biceps and triceps muscles in individuals, comparisons can be made regarding the relative strength of the two muscles. Suggest **one** feature of the human subjects that should be controlled to make any conclusions valid. [1]

.....

Even when the head is held erect, its centre of gravity is not directly over the principal point of support (the atlanto-occipital joint). The muscles at the back of the neck exert a force to keep the head erect. That is why your head falls forward when you fall asleep.



**Key:**  
**CG = centre of gravity**

- (iv) Using the formula below, calculate the force needed to hold the head erect in the position shown [2]

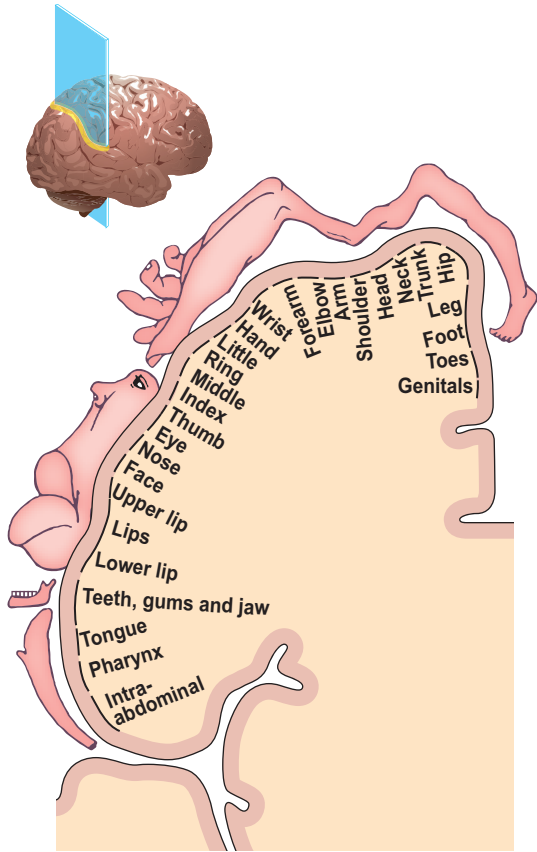
$$F_1 \times d_1 = F_2 \times d_2$$

Force = ..... N

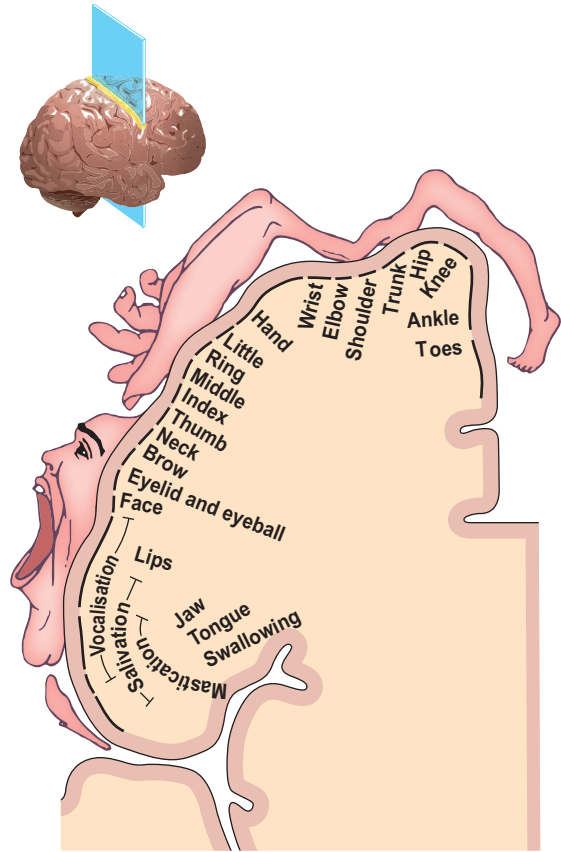
|    |
|----|
|    |
| 20 |

**Option C: Neurobiology and Behaviour**

3. (a) The cortical homunculus is a drawing showing the area of cortex devoted to specific regions of the body. It correlates the anatomy of the body with a neurological map. There are two types of cortical homunculus: the sensory homunculus and the motor homunculus.



Sensory cortex in right cerebral hemisphere



Motor cortex in right cerebral hemisphere

With reference to the homunculi shown above, identify what they show and describe and explain the major differences between the two images. [4]

.....

.....

.....

.....

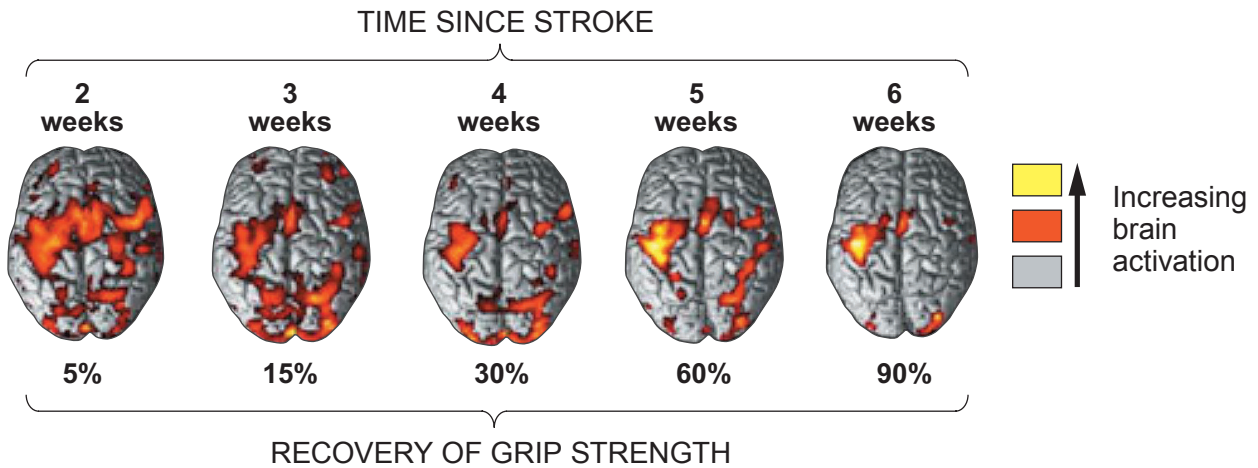
.....

.....

.....

.....

(b) A stroke is the interruption of blood flow to the brain. It may result in the death of brain cells. Individual patients can recover from strokes over a period of time. The image below shows functional magnetic resonance imaging (fMRI) scans showing the brain during repetitive gripping with the hand. Each brain image represents the activation pattern at different time points over the first six weeks after a stroke for one patient. After 6 weeks, the image is very similar to what is seen during learning of a new complex motor task in the undamaged human brain.



(i) With reference to the image, describe the advantage of fMRI over computerised tomography (CT) and magnetic resonance imaging (MRI) scans. Explain what has happened in the brain in order to recover from the stroke. [3]

.....

.....

.....

.....

.....

.....

.....

(ii) Some studies suggest that in a healthy person 375 neurones per hour die due to the aging process. In an untreated stroke patient, it is estimated that 1.9 million neurones per minute die. Calculate how many times greater the neurone loss is in a patient who has a stroke that is untreated for 1 hour compared to a healthy person. [2]

Times greater = × .....

- (iii) Use the scans opposite to suggest which part of the brain was damaged. Give reasons for your answer. [2]

.....

.....

- (iv) A stroke affecting Wernicke's area has a different affect to a stroke affecting Broca's area. Using your knowledge of these areas of the cerebral cortex describe the effect of each type of stroke. [2]

.....

.....

.....

.....

**Question is continued on the next page**



- (c) Meerkats, *Suricata suricatta*, live in social groups called mobs, of 5-30 individuals. They inhabit open dry land such as the Kalahari desert. Meerkats share parental care responsibilities. Each mob has a dominant alpha male and dominant alpha female. These are usually the only individuals who produce offspring. This social structure is referred to as a dominance hierarchy.



- (i) What are the advantages, to the meerkat colony, of this dominance hierarchy? [2]

.....

.....

.....

.....

.....

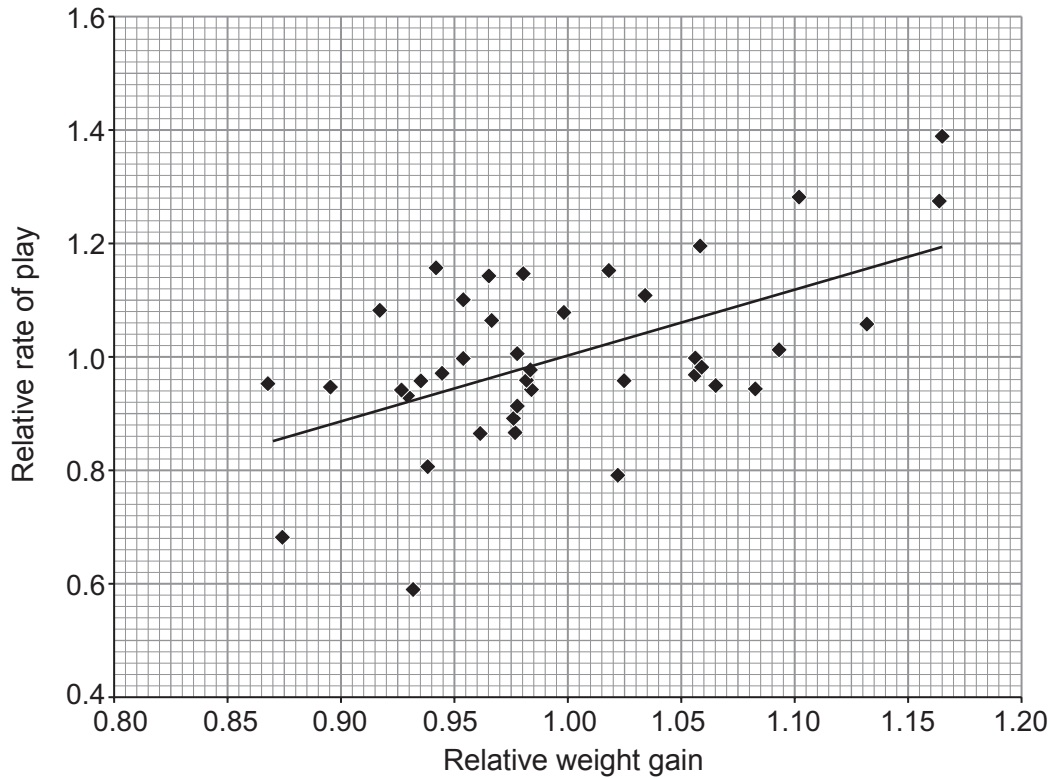
- (ii) There is little difference between the size of males and females in meerkats. In other mammals, however, such as African lions, *Panthera leo*, the male is much larger than the female. Explain the reason for the large size of the male lions. [1]

.....

.....

.....

- (d) A study of 39 wild meerkats in South Africa investigated whether engaging in play behaviour was more likely in individuals in a better nutritional state. The meerkats were habituated to close observation and handling, they were individually marked and regularly weighed. The researchers observed play in the early morning. They calculated the mean play rates for the young meerkats and compared the individual play rates to the mean. The results are shown in the scatter graph below.



- (i) What is the advantage to the study of using meerkats 'habituated' to close observation and handling? [1]

.....

.....

- (ii) What type of correlation is shown between relative weight gain and relative rate of play? [1]

.....

- (iii) How could this investigation be improved to give more valid data? [2]

.....

.....

.....

**END OF PAPER**